BC SCIENCE 10

Provincial Exam Study Guide

Unit 4: Energy Transfer in Natural Systems

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Part A Strategies for Success

Study Tips for Provincial Exam Preparation

Introduction

This guide is designed to help you study for the BC Science 10 provincial exam. Completing all the questions in this Study Guide will not guarantee that you will pass the exam, but it will help prepare you for success.

Each unit in this Study Guide matches up to a unit in your *BC Science 10* student book. Each Study Guide unit begins with a checklist of what you should be able to do by the end of that unit. You can use this checklist to help you figure out which concepts you already know and which concepts you need to study further. Each Study Guide unit ends with a checklist of Processes of Science Vocabulary Terms that you should know and a Glossary of terms from the unit that you should understand.

Each section in the Study Guide has the following features.

- Summary of Key Points—you must know each of these key points for the exam
- Study Notes—these are the key points expanded to include details that may be on the exam
- Quick Check—these are questions to check your understanding of the Study Notes. If you cannot answer Quick Check questions, review the material in your student book or talk to your teacher.
- Sample Exam Questions Explained—this feature explains in detail the right and wrong answers for questions that are similar in style to the questions that will be on the provincial exam. The feature also describes why each question was asked and where you can get additional help if you did not understand the question. One strategy to help you study is to cover up the right-hand column in the question and try to answer the question first. Then, uncover the column to check your answer or to figure out why an answer is wrong. Figuring out why you got an answer wrong can help you to learn the concept.
- Practice Questions—these are questions that are similar in style to the questions that will be on the provincial exam. There are 10 Practice Questions at the end of each section.

Support for Studying

When you study for the provincial exam, you should have the following materials. If you are missing any of the items below, please see your teacher.

- ***BC Science 10* student book** Your student book covers the same curriculum that the provincial exam was developed for. It is an excellent source of information for studying.
- **Your notes** Your teacher has worked the whole semester or school year with you to help you develop the right knowledge, skills, and attitudes. A key part of this work is the notes you have created. Remember to review these notes while you study.
- **BC Science 10 Provincial Exam Data Pages** It is very important that you understand the parts of the Provincial Exam Data Pages and how to use them. Your teacher can answer your questions about these pages.
- **BC Science 10 Provincial Exam Vocabulary List** You should know the meaning of each of these terms. If you are unsure of any of the terms, check the Glossary at the end of each Study Guide unit or at the back of your student book.
- **The BC Science 10 website** You can find practice questions and web links that will help you study the material you have covered in Science 10 this year. Visit www.bcscience10.ca.

Getting Help

When you study for a year-end test like the provincial exam, it is not uncommon to get stuck on concepts or have questions on material you have previously covered in class. If you are unsure about a concept or something covered in class, check with a classmate first. If both of you cannot figure out the answer, visit your teacher together.

Tips from Experts

Study experts have a common list of hints they provide to people of all ages. Research has shown that these tips help you study.

- Have a **positive attitude.**
- **Be motivated** and take responsibility for your learning.
- **Attend class** so you do not miss key points about what you are learning. Your friend's notes are not a replacement for being present in class and learning the concepts while they are being taught.
- **Study regularly** to help you identify areas where you need extra help.
- **Get help** when you need it, and do not be afraid to ask questions. There are no bad questions when it comes to figuring something out.
- **Be a good test taker.** Have a good sleep the night before the test and be sure to eat a nutritious breakfast the day of the test. During the test, read each question carefully before selecting your answer.

Here is a list of common hints that science teachers in British Columbia have shared with their students.

- Know how to use your Data Pages.
- Practise reading graphs.
- Practise interpreting illustrations.
- Do not spend extra time studying what you already know.
- When you are writing the exam, read the question first, then read the possible answers. If you do not know the answer, then look at the picture (if there is a picture).
- Take your time when you write the exam. Answer the questions you know first, and then go back to questions that you are not sure of.

Part B: Unit Study Notes and Exam Questions

Unit 4 Energy Transfer in Natural Systems

By the end of this unit, you should be able to:

1. Explain the characteristics and sources of thermal energy
   This includes being able to:
   - ☐ define *heat* and *thermal energy*
   - ☐ explain and illustrate how thermal energy is transferred through conduction, convection, and radiation, with reference to
     - kinetic molecular theory
     - practical examples (e.g., home heating, cooking methods, loss of body heat, insulation)
   - ☐ describe Earth's energy sources, including
     - residual thermal energy from Earth's formation
     - energy from radioactive decay
     - solar energy (with reference to absorption and radiation in the atmosphere)

2. Explain the effects of thermal energy within the atmosphere
   This includes being able to:
   - ☐ define *atmospheric pressure* and explain how it is measured
   - ☐ identify weather conditions that typically accompany areas of low and high pressure in the atmosphere
   - ☐ describe how energy transfer influences atmospheric convection, atmospheric pressure, and prevailing winds (e.g., differential heating of land and water causes changes in air density and affects prevailing winds)

3. Evaluate possible causes of climate change and its effect on natural systems
   This includes being able to:
   - ☐ describe how natural phenomena can affect climate (e.g., biosphere processes, volcanic eruptions, Coriolis effect, El Niño and La Niña)
   - ☐ describe how climate can be influenced by human activities (e.g., greenhouse gases, depletion of ozone layer)
   - ☐ describe how climate change affects natural systems (e.g., shrinking of the permafrost region, melting of ice shelves/icecaps/glaciers)

4. Analyze the processes and features associated with plate tectonics
   This includes being able to:
   - ☐ define *plate tectonics, plate boundary, earthquake, trench, volcano, spreading ridge, subduction zone, hot spot*
   - ☐ relate tectonic plate movement to the composition of the following layers of Earth, as determined by seismic waves (primary, secondary, and surface waves):
     - crust
     - lithosphere
     - asthenosphere
     - mantle
     - outer core
     - inner core
   - ☐ describe tectonic plate boundaries, including
     - transform boundaries
     - divergent boundaries
     - convergent boundaries (oceanic-oceanic crust, oceanic-continental crust, and continental-continental crust)

- ☐ identify tectonic mapping symbols
- ☐ explain how plate movement produces the following features:
  - epicentres and shallow-focus to deep-focus earthquakes
  - volcanism at subduction zones (e.g., volcanic island arcs, volcanic belts) and at spreading ridges
  - mountain ranges and mid-ocean ridges
  - hot spot chains (e.g., Hawaiian Islands, Yellowstone)
- ☐ identify sources of heat within Earth that produce mantle convection and hot spot activity (i.e., heat within the core and excess radioactivity within the mantle)
- ☐ explain how mantle convection and ridge push and slab pull are believed to contribute to plate motion

5. Demonstrate knowledge of evidence that supports plate tectonic theory
   This includes being able to:
   - ☐ describe evidence for continental drift theory (e.g., fossil evidence, mountain belts, paleoglaciation)
   - ☐ relate the following to plate tectonic theory:
     - the world distribution of volcanoes, earthquakes, mountain belts, trenches, mid-ocean ridges, and rift valleys
     - hot spot and subduction zone eruptions
     - magnetic reversals and age of rocks relative to spreading ridges

By the end of this unit, you should understand the following key ideas:

1. The kinetic molecular theory explains the transfer of thermal energy.
2. Climate change occurs through natural processes and human activities.
3. Thermal energy drives plate tectonics.

To help you study, you should have the following:

- *BC Science 10* student book pages, 418 to 549. Note the practice exam questions on pages 548 and 549.
- BC Science 10 Provincial Exam Data Pages, pages 7, 10, and 11
- BC Science 10 Provincial Exam Vocabulary List, pages 2 and 3
- Access to www.bcscience10.ca

Chapter 10 The kinetic molecular theory explains the transfer of thermal energy.

10.1 Temperature, Thermal Energy, and Heat

I. Summary of Key Points

- The kinetic molecular theory explains that particles in matter are in constant motion.
- Matter has thermal energy due to the kinetic and potential energies of its particles.
- Heat is the amount of thermal energy transferred from a warmer area to a cooler one.
- Heat transfer occurs by collisions between particles (conduction), the movement of fluids (convection), or the movement of electromagnetic waves (radiation).

II. Study Notes

The Kinetic Molecular Theory

1. The **kinetic molecular theory** explains that all matter is made up of tiny particles (atoms and molecules) that are constantly in motion.
   - **Kinetic energy** is energy due to motion.
2. The particles of a substance move differently for different states (Figure 10.1).
   - In solids, particles vibrate slowly but do not change position.
   - In liquids, particles vibrate more and move around within a set volume.
   - In gases, particles vibrate greatly and move around to take all the available volume.

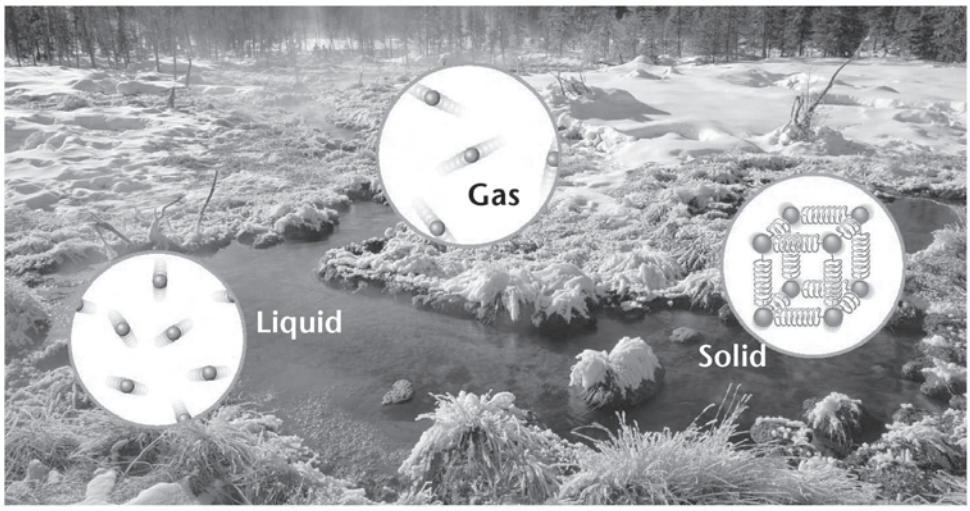


FIGURE 10.1 Particles in a solid are strongly attracted to one another. Particles in liquids and gases move freely and are spread farther apart.

Temperature, Thermal Energy, and Heat

1. **Temperature** is a measure of the average of the kinetic energy of all the particles in a sample of matter.
   - Temperature is measured in degrees Fahrenheit (F), Celsius (C), and Kelvin (K).
     Examples: Water freezes at 32°F, 0°C, and 273 K.
2. **Thermal energy** is the total energy of all the particles in a solid, liquid, or gas.
   - Thermal energy = all kinetic energy + all potential energy
   - **Potential energy** is the stored energy of an object or particle, due to its position or state.
3. **Heat** is the amount of thermal energy that transfers from an area or object of higher temperature to an area or object of lower temperature.
   - **Heat flow** is the movement of thermal energy from a hotter object to a colder object.

Quick Check

1. What does the kinetic molecular theory explain? _____

   _____

   _____

2. Define temperature. _____

   _____

3. Define thermal energy. _____

   _____

4. Define heat. _____

   _____

5. Compare a boiling hot cup of tea to an iceberg floating in the ocean.

   (a) Which has greater thermal energy? _____

   (b) Which has particles with the highest average kinetic energy? _____

   (c) Which has more potential energy? _____

   (d) If placed together, would heat flow from the tea to the iceberg or from the iceberg to the tea?

   _____

Heat Transfer, Conduction, Convection, and Radiation

1. **Conduction** is the transfer of heat by direct contact of particles.
   - Heat is transferred across a temperature gradient, from higher temperature, higher kinetic energy particles to lower temperature, lower kinetic energy particles.
     – A temperature **gradient** is a region where the temperature changes from one measure to another.
     Example: A cold spoon warms when placed in a cup of hot chocolate.
   - Thermal conductors transfer heat easily.
   - Thermal **insulators** are materials that do not transfer heat easily.
2. **Convection** is the transfer of heat energy in fluids where hot, less dense fluid rises and cold, denser fluid sinks.
   - Fluids are substances that can flow, including liquids and gases.
   - Density is the amount of mass contained in a given volume.
   - A convection current is the movement of a fluid caused by density differences.
3. **Radiation** is the transfer of energy by waves through space.
   - Infrared radiation or heat radiation is the transfer of radiant energy such as from the Sun or a campfire.
4. Earth's energy sources include:
   - thermal energy left over from Earth's formation
   - the decay of radioactive elements underground
   - solar radiation (energy from the Sun), including visible light as well as infrared and other types of radiation

Quick Check

1. What are the names of the three ways that heat flow can occur?

   _____

   _____

   _____

2. Which kind of heat flow can occur when two solids come in contact?

   _____

3. Which kind of heat flow needs no contact and can even occur in empty space?

   _____

4. Which kind of heat flow involves the motion of a fluid from one place to another?

   _____

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
As a piece of gold is heated, it can change from one state to another state. Which series below lists the states of matter according to particle speed, from slowest to fastest?	
A. solid, liquid, gas	A. This answer is correct. According to the kinetic molecular theory, the particles in a solid move the slowest and those in a gas move the fastest.
B. liquid, gas, solid	B. Gases move with the greatest amount of speed.
C. gas, solid, liquid	C. Gases move with the greatest amount of speed.
D. gas, liquid, solid	D. Gases move with the greatest amount of speed.

➜ Why was this question asked?

This question was asked to determine if you understand the kinetic molecular theory and its description of the motion of particles.

➜ Where can I get extra practice on this type of question?

- Use pages 423 to 431 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
Which form of heat transfer requires the motion of particles from one place to another?	
A. radiation	A. Radiation is the transfer of electromagnetic energy and occurs without matter.
B. convection	B. This answer is correct. In convection, particles move from one place to another, carrying their energy with them.
C. conduction	C. Conduction is the transfer of thermal energy through contact between two objects, but the matter in the objects is not transferred.
D. radiation, convection, and conduction	D. Only convection involves the movement of particles.

➜ Why was this question asked?

This question was asked to determine if you understand mechanisms of heat transfer through conduction, convection, and radiation.

➜ Where can I get extra practice on this type of question?

- Use pages 426 to 431 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 10.1

The kinetic molecular theory explains the transfer of thermal energy: Temperature, Thermal Energy, and Heat

Circle the letter of the best answer.

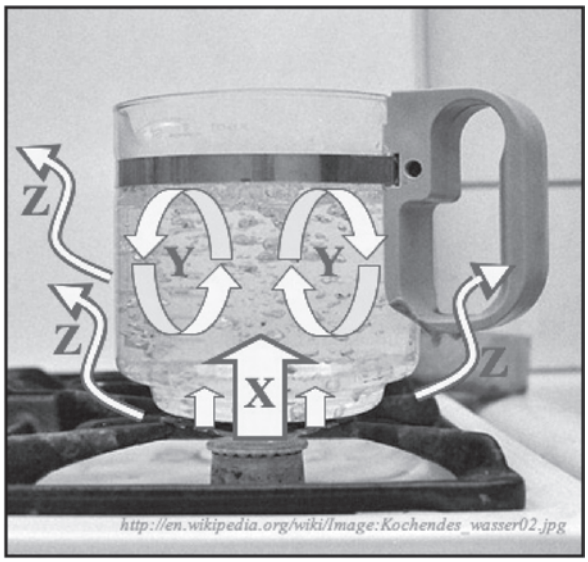
1. Which phrase below best describes thermal energy?
   A. the transfer of heat from one object to another
   B. the total energy of all the particles in a solid, liquid, or gas
   C. the random movements of all the particles in a sample of matter
   D. the average kinetic energy of all the particles in a sample of matter

2. What form of heat transfer does **not** require the presence of particles?
   A. radiation
   B. convection
   C. conduction
   D. All heat transfer requires particles for transmission.

3. At which of the following temperatures does water change from liquid to solid?
   A. 0°C
   B. 0 K
   C. 0°F
   D. all of the above

4. Many homes are heated by a forced air furnace, from which hot air is pumped into a room through a vent, and the cold air is then forced out of the room through a cold air return. What type of transfer of heat is happening in this situation?
   A. radiation
   B. convection
   C. conduction
   D. There is no heat being transferred in this process.

Use the image of a container of boiling water below to answer questions 5 and 6.



5. What type of heat transfer is represented by X?
   A. radiation
   B. convection
   C. conduction
   D. boiling

6. If you were to grab the sides of this hot container, what form of heat transfer would you experience?
   A. radiation
   B. convection
   C. conduction
   D. boiling

7. Which of the following has particles with the greatest average kinetic energy and the least amount of thermal energy?
   A. a boiling pot of water
   B. a bath tub full of lukewarm water
   C. the flame of a candle
   D. a lake with a layer of ice on its surface

8. Why does a piece of metal expand when it heats up?

   A. The particles vibrate faster and move farther apart.
   B. The particles vibrate slower and move farther apart.
   C. The particles get larger and take up more volume.
   D. The particles break their bonds and begin to slide past each other.

9. Put the following systems in order of least thermal energy present to greatest thermal energy present.

I	a boiling kettle at 98°C
II	an ocean at 10°C
III	an ice cube at −4°C
IV	a swimming pool at 28°C

   A. II, IV, I, III
   B. III, I, IV, II
   C. III, II, IV, I
   D. IV, I, II, III

10. Which of the following is a good thermal insulator?

   A. a soft drink can
   B. a piece of glass
   C. a piece of foam
   D. a copper-bottomed pot

10.2 Energy Transfer in the Atmosphere

I. Summary of Key Points

- Life on Earth depends on the atmosphere.
- Solar radiation transfers heat to Earth.
- Conduction and infrared radiation from Earth's surface help to heat the atmosphere.
- Atmospheric pressure, air temperature, and humidity vary throughout the atmosphere.
- Differences in atmospheric conditions affect, and are affected by, convection in the atmosphere.
- Weather is the condition of the atmosphere at a specific time and place.

II. Study Notes

The Layers of the Atmosphere

1. The **atmosphere** includes layers of gases that extend above Earth.
   - Air is a combination of gases near Earth's surface, made of about 78 percent N_2 and 21 percent O_2, with traces of other gases, such as argon and carbon dioxide.
2. The density of the atmosphere decreases with altitude.
3. The *troposphere* is the closest layer to Earth's surface and ranges from 8 km to 16 km thick (about 10 km on average).
   - This is the highest density layer because all other layers compress it.
   - Almost all water vapour in the atmosphere is found here, and most weather takes place here.
   - Solar energy and thermal energy from Earth keep air moving in this layer.
   - Temperature ranges from an average of 15°C at the bottom to –55°C at the top.
4. The *stratosphere* is above the troposphere and extends 10 km to 50 km above Earth, warming from –55°C as altitude increases.
   - This layer has strong, steady winds, so airplanes often fly here to avoid the turbulent troposphere.
   - The ozone layer is found here, which blocks harmful ultraviolet radiation.
5. The upper atmosphere includes the *mesosphere*, *thermosphere*, and *exosphere* and extends from 50 km above Earth into space.

Quick Check

1. Which two gases make up about 99 percent of the atmosphere?

   _____

   _____

2. Are air particles closer together on a mountain top or at sea level?

   _____

3. What two sources of energy cause the air in the troposphere to keep mixing?

   _____

   _____

Radiation and Conduction in the Atmosphere

1. Almost all of the thermal energy on Earth comes from the Sun.
   - Most thermal energy is transferred near the equator, which receives more direct rays from the Sun than do the regions closer to the poles.
2. Earth's surface absorbs solar radiation, heats up, and then radiates the thermal energy into the atmosphere.
3. Earth has a balance of incoming and outgoing energy called the **energy budget**, **heat budget**, or radiation budget (Figure 10.2).
   - About 15 percent of incoming solar radiation is reflected by clouds, 7 percent is reflected by dust, and 20 percent is absorbed by clouds and the atmosphere.
   - The remaining 58 percent of incoming solar radiation reaches Earth's surface.
   - About 9 percent of incoming solar radiation is reflected back to space by Earth's surface.
4. Conduction transfers heat in the lowest part of the atmosphere, near Earth's surface.
   - The ground transfers heat to particles in the air directly above it.

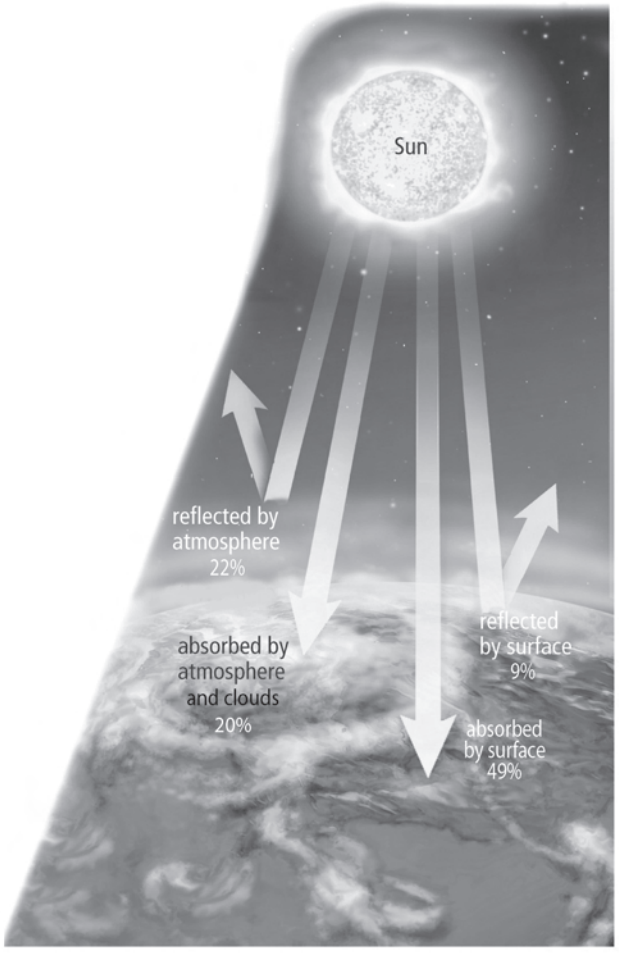


FIGURE 10.2 Earth's energy budget

What Is Weather?

1. Weather is the conditions in the atmosphere at a particular place and time.
   - Weather describes temperature, atmospheric pressure, amount of moisture in the air, and wind speed and direction.
2. Convection currents in the air spread the thermal energy around by causing some air masses to rise and other air masses to fall.

Quick Check

1. What happens when Earth's surface absorbs radiation?

   _____

2. What is Earth's energy budget a balance between?

   _____

3. What role do convection currents play in creating weather?

   _____

Atmospheric Pressure

1. **Atmospheric pressure** is the amount of pressure the molecules in the atmosphere exert at a particular location and time.
   - **Pressure** is the amount of force per unit area.
2. Atmospheric pressure is measured with a **barometer**.
   - The SI unit for atmospheric pressure is the pascal (Pa), which has a force of 1 newton per square metre = 1 N/m^2
   - 1 kilopascal (kPa) = 1000 Pa
   - At sea level, the atmospheric pressure is about 101.3 kPa.
3. Atmospheric pressure is affected by altitude, temperature, and humidity.
4. Atmospheric pressure decreases with altitude because air is less dense as altitude increases.
   - Your ears may "pop" on a mountain road to help balance pressure inside your ears with pressure on the outside.
5. Warm air is lighter and less dense than cool air and so warm air has a lower pressure than cool air.
6. The amount of moisture that evaporates into the air affects the weather.
   - **Evaporation** is the change of state of a substance from liquid form to gas form.
     - More evaporation occurs with warm, dry air over a warm lake or ocean.
     - Humid air (air with more water vapour) has lower pressure than dry air.
     - When the atmospheric pressure drops, warm, moist air is arriving in the area.

Movement of Air Masses

1. **Wind** is the movement of air from an area of higher pressure to an area of lower pressure.
2. An air mass is a large body of air with similar temperature and humidity throughout.
   - Air masses take on the conditions of the weather below.
   - Air masses can be as large as an entire province or even larger.
3. High pressure systems form when an air mass cools.
   - High pressure systems usually occur over cold water or land.
   - Winds blow clockwise around the centre of the high (Figure 10.3 on next page).
   - As the high pressure air sinks, it becomes warmer and drier. As a result, high pressure systems often bring clear skies.

4. Low pressure systems form when an air mass warms.
   - Low pressure systems usually occur over warm water or land.
   - Winds blow counterclockwise around the centre of the high (Figure 10.3).
   - As the low pressure system rises, it cools and condensation occurs. As a result, low pressure systems often produce clouds or precipitation.
     - **Condensation** is the change of state of a substance from gas form to liquid form, such as from water vapour to liquid water.

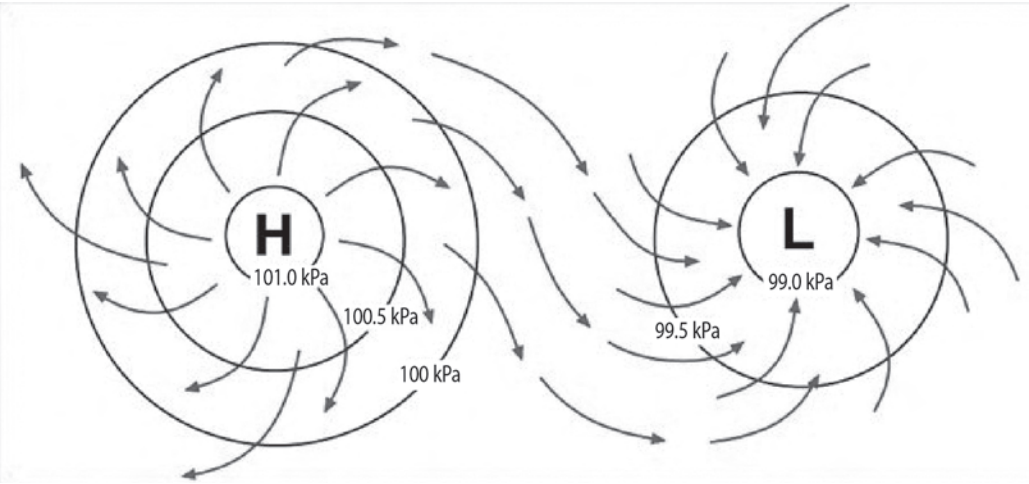


FIGURE 10.3 Examples of high pressure and low pressure systems

Quick Check

1. (a) What is atmospheric pressure? _____

   _____

   (b) What instrument is used to measure atmospheric pressure? _____
2. Is air pressure greater on a mountain top or at sea level? _____
3. Why does warm air have a lower pressure than cool air? _____

   _____
4. What causes wind? _____

   _____
5. Why do high pressure air mass systems often bring clear skies? _____

   _____

   _____
6. Why do low pressure air mass systems often bring precipitation? _____

   _____

   _____

Prevailing Winds

1. **Prevailing winds** are winds that are typical for a location.
2. Prevailing winds in southern British Columbia are moist air masses from the Pacific Ocean that blow inland over the coastal mountains (Figure 10.4).
   - Cool temperatures and high altitudes cause water vapour to condense, forming rain or snow, so that the prevailing winds have lost most of their moisture by the time they reach interior British Columbia.

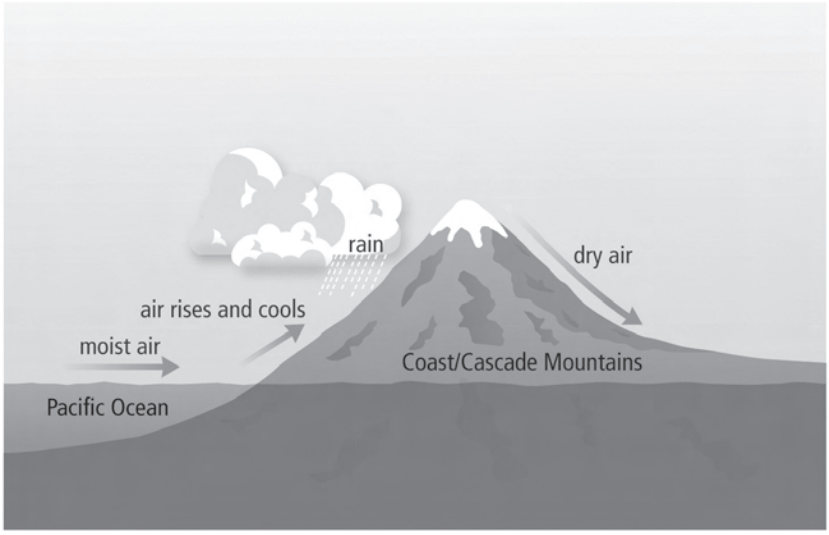


FIGURE 10.4 Prevailing winds in southern British Columbia blow inland over coastal mountains.

3. **Surface winds** are winds near Earth's surface that are subjected to friction from the differences in geographic features.
   - Hills and forests force the winds to slow down and change direction, whereas a calm ocean surface does not create as much friction.
4. Sea breezes are local winds that are caused by different rates at which land and water respond to heating and cooling.
   - Onshore breezes usually occur during the late morning along coastal regions as the warm air over the land rises and cool air from over the water is drawn inland.
   - Offshore breezes usually occur at night when warm air over the water rises and draws in the cool air from over the land.

Quick Check

1. What are the prevailing winds in southern British Columbia? _____

   _____

2. How can hills and forests affect surface winds? _____

   _____

3. What is the name of the sea breezes that occur when warm air over the water rises and draws in the cool air from over the land? _____
4. What is the name of the sea breezes that occur as the warm air over the land rises and cool air from over the water is drawn inland? _____

The Coriolis Effect, Global Winds, and Jet Streams

1. The **Coriolis effect** is a change is the direction of moving air, water, or objects due to Earth's rotation.
   - As Earth rotates, any location at the equator travels much faster than a location near either pole.
   - Air rising from the equator travels east quickly in the same direction that Earth rotates, causing circulating air to curve to the side (Figure 10.5).

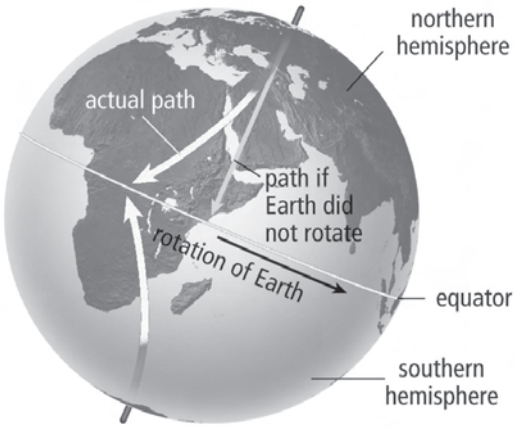


FIGURE 10.5 The Coriolis effect causes circulating air to curve to the side.

2. Convection currents and the Coriolis effect create Earth's three major global wind systems that occur in both hemispheres: the trade winds, the prevailing westerlies, and the polar easterlies (Figure 10.6).

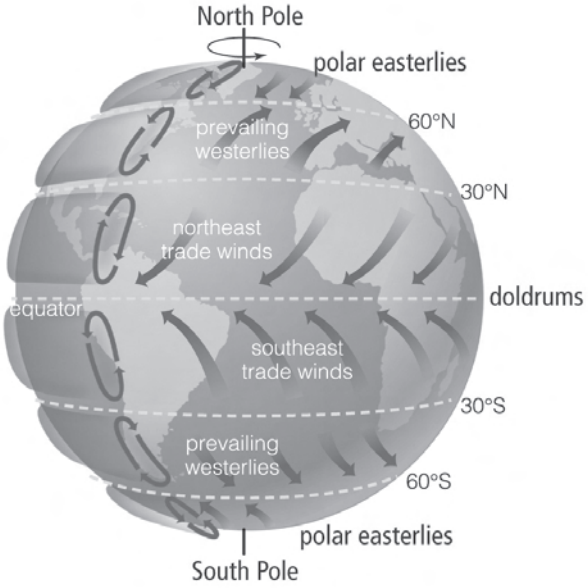


FIGURE 10.6 Convection currents and the Coriolis effect create Earth's global wind systems.

3. A jet stream is a band of fast-moving air in the stratosphere, where winds are subject to less friction and can move much faster than winds in the troposphere.
   - Airplane pilots try to fly with these winds and avoid trying to fly against them.

Fronts and Extreme Weather

1. A front is a boundary between two air masses.
2. Air masses often have very large amounts of thermal energy.
   - Extreme weather can arise under certain conditions as this energy is released.
3. Thunderstorms can occur when warm air rises and water condenses, which releases energy.
   - Sea breezes in the tropics and energetic cold and warm fronts can cause thunderstorms.
   - Static energy can be built up and released as lightning.
   - Lightning superheats the air, causing it to expand rapidly and then collapse, creating the sound of thunder.
4. Tornadoes can form when high altitude horizontal winds meet thunderstorms.
   - A **tornado** is a "funnel" of rotating air, which sometimes extends all the way to the ground with winds of up to 400 km/h.
   - When tornadoes form over water, waterspouts can occur.
5. The tropics can often have severe weather, such as **hurricanes**, which are storm systems with a low pressure centre that have strong winds, flooding rains, and many thunderstorms.
   - Large masses of warm, moist air rise quickly and release thermal energy as the water vapour condenses.
   - The Coriolis effect forces the air to rotate counterclockwise in the northern hemisphere, clockwise in the south.
   - Hurricane wind speeds may reach up to 240 km/h.
   - Hurricanes are also called tropical cyclones or typhoons.

Quick Check

1. What is the Coriolis effect? _____

   _____

2. List the three major global wind systems in the order in which they occur from the equator to the poles.

   _____

   _____

   _____

3. What is a weather front? _____
4. What causes extreme weather events? _____

   _____

5. List three kinds of extreme weather.

   _____ _____ _____

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
On a certain coastline, early evening offshore winds (blowing from the land out to the ocean) occur. What is the most likely reason for this?	
A. The land remains warmer at night, which generates offshore winds.	A. Land cools more quickly than water.
B. The ocean remains warmer at night, which generates onshore winds.	B. While the water does remain warmer, this would lead to offshore winds, not onshore winds.
C. There is rapid cooling of land at night, which generates offshore winds.	C. This answer is correct. Land cools down faster than nearby water. The relatively warm air over the water rises and draws cool air from land out over the water.
D. There is rapid cooling of water at night, which generates offshore winds.	D. Water keeps a relatively constant temperature between day and night. It is the land that changes temperature quickly.

➜ Why was this question asked?

This question was asked to determine if you can explain how local winds are generated on a coastline.

➜ Where can I get extra practice on this type of question?

- Use pages 448 and 449 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
What type of weather can be expected when a weather forecast predicts a low-pressure system for the day?	
A. thunderstorms	A. A thunderstorm is a severe weather condition and is not likely to occur just because a low-pressure system is formed.
B. unsettled weather conditions	B. Unsettled weather conditions are more likely to result at the boundary between two air masses where mixing of air with different pressures, temperatures, and moisture content occurs.
C. clear skies	C. Clear skies occur in a high-pressure system. High-pressure air tends to sink, making it warmer and able to hold increased amounts of water moisture as a gas. This causes the water droplets that form clouds to evaporate. Clear skies are the result.
D. cloudy skies	D. This answer is correct. A low-pressure system is created when an air mass is warmed over land. The warming causes the air to expand and rise. This causes the air to cool, which also results in water vapour condensing to form tiny water droplets. Many of these droplets join together to become clouds.

➜ Why was this question asked?

This question was asked to determine if you can identify weather conditions that typically accompany areas of low and high pressure in the atmosphere.

➜ Where can I get extra practice on this type of question?

- Use pages 447 and 448 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 10.2

The kinetic molecular theory explains the transfer of thermal energy: Energy Transfer in the Atmosphere

Circle the letter of the best answer.

1. Which of the following definitions best describes the term "atmosphere"?
   A. a partly molten layer of Earth's upper mantle
   B. constant layer of dry air that has virtually no clouds
   C. the layer of gas that extends above a planet's surface
   D. a dense layer of gases that extends anywhere from 6 km to 16 km from the surface of Earth

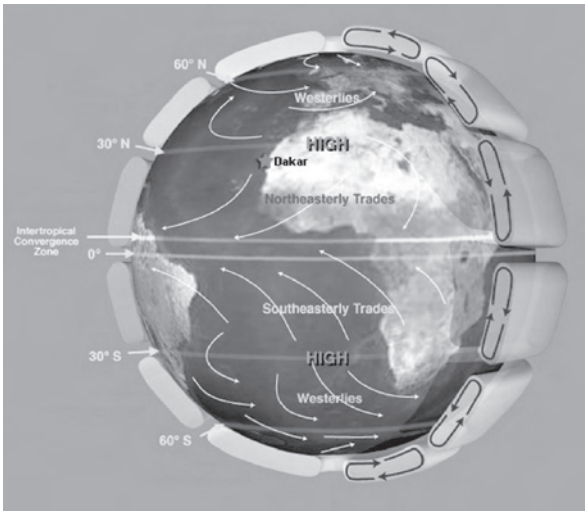
2. What are the four most abundant components of Earth's atmosphere?
   A. hydrogen, nitrogen, carbon dioxide, and oxygen
   B. hydrogen, oxygen, argon, and carbon dioxide
   C. nitrogen, oxygen, carbon dioxide, and argon
   D. nitrogen, oxygen, ozone, and carbon dioxide

3. Which of the following forms of heat transfer contribute to global wind patterns?

I	convection
II	conduction
III	solar radiation

   A. I only
   B. III only
   C. I and II only
   D. I, II, and III

Use the following image to help answer question 4.



4. If you live in Dakar, on the west coast of Africa, what would you expect the wind to be like on a warm summer evening?
   A. an offshore breeze (from land onto the water) with a northeast trade wind
   B. an offshore breeze (from land onto the water) with a prevailing westerly
   C. an onshore sea breeze (from water onto the land) with a southeast trade wind
   D. an onshore sea breeze (from water onto the land) with a prevailing westerly

5. What is the reason for the Coriolis effect?
   A. the rising of hot air masses at the equator and then falling at 30° latitude
   B. the cooling of land masses faster than oceans that they border
   C. atmospheric pressure
   D. rotation of Earth

6. The usual direction of wind in the southern interior of British Columbia is in a western direction. What would you call this type of wind?

   A. a local wind
   B. a prevailing wind
   C. an onshore breeze
   D. an offshore breeze

7. What is the most likely reason why flights from Vancouver to Toronto take less time than flights from Toronto to Vancouver?

   A. Pilots take advantage of the high pressure systems that form on the coast of British Columbia to push them east.
   B. Pilots have to deal with large amounts of turbulence as they leave the Great Lakes heading west.
   C. Pilots are flying in the direction of Earth's rotation when they are flying east.
   D. Pilots can take advantage of the jet stream when travelling east.

8. You are watching the weather station and the meteorologist informs you that there will be a high pressure system in your area tomorrow. What type of weather would you predict?

   A. a storm
   B. clear skies
   C. precipitation
   D. unstable weather

9. Which of the following is the term used to describe a change in the direction of moving air, water, or objects due to Earth's rotation?

   A. pressure differential
   B. prevailing winds
   C. Coriolis effect
   D. jet stream

10. Which of the following are key features of a tornado?

I	high-altitude, horizontal winds
II	accompanied by a thunderstorm
III	may have wind speeds of 400 km/h
IV	results from an exchange of thermal energy in the tropics

   A. I only
   B. I and II only
   C. I, II, and III only
   D. I, II, III, and IV

Chapter 11 Climate change occurs through natural processes and human activities.

11.1 Natural Causes of Climate Change

I. Summary of Key Points

- Climate describes a region's long-term weather patterns.
- Geological evidence shows that Earth has undergone many climate changes, including ice ages and periods of warming.
- The processes that contribute to climate change are complex and include factors that affect Earth's radiation budget and heat transfer around the globe.
- Scientists have identified several factors that affect climate: greenhouse gases in the atmosphere, Earth's tilt and orbit, heat transfer by the oceans, and catastrophic events, such as volcanic eruptions and meteor impacts.

II. Study Notes

Describing Climate and **Looking Forward by Studying the Past**

1. Climate describes the average conditions of a region over 30 years or more, including clouds, precipitation, average temperature, humidity, atmospheric pressure, solar radiation, and wind.
2. To understand our climate now and predict future climates, paleoclimatologists study evidence of past climates using fossils, tree rings, glacier ice cores, etc.
3. Evidence shows Earth's climate has dramatically changed in the past, including ice ages and periods of warming.

Quick Check

1. What is meant by the term "climate"? _____

   _____

2. List three kinds of evidence can be used to study climate changes that have occurred in the past.

   _____

   _____

   _____

The Composition of Earth's Atmosphere

1. The natural greenhouse effect is the absorption of thermal energy by the atmosphere, which keeps Earth's temperature within a certain range.
2. **Greenhouse gases** are atmospheric gases, such as water vapour and carbon dioxide, that absorb and emit radiation as thermal energy.
   - Greenhouse gases keep Earth an average of 34°C warmer than it would be otherwise.
   - More greenhouse gases in the atmosphere would make Earth much warmer.

Earth's Tilt, Rotation, and Orbit around the Sun

1. Earth's tilt is responsible for seasons in northern hemisphere (Figure 11.1).
   - In summer, the northern hemisphere is tilted toward the Sun, increasing the amount of solar radiation.
   - In winter, the northern hemisphere is tilted away from the Sun, decreasing the amount of solar radiation.
   - Earth's tilt varies between 22.3° and 24.5° (currently 23.5°) in 41 000 y cycles.
     – Our climate may experience the largest extremes when the tilt is the greatest.

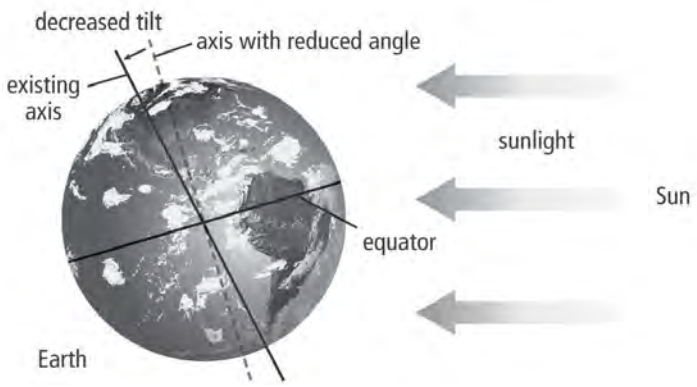


FIGURE 11.1 Earth rotates on an axis that is tilted 23.5° relative to Earth's orbit around the Sun. Earth's tilt affects the angle of incidence of the Sun's rays.

2. Earth "wobbles" as it rotates on its axis.
   - Because the axis changes on a 23 000 y cycle, the angle of incidence of solar radiation also changes.
3. Earth's orbit around the Sun is elliptical, not circular.
   - The shape of Earth's orbit changes over a period of 100 000 y.
   - When Earth is farther from the Sun, it receives less solar radiation.

Quick Check

1. What is the natural greenhouse effect? _____

   _____

2. How much cooler would Earth be on average without the natural greenhouse effect? _____
3. List three types of motion that influence Earth's climate.

   _____ _____ _____

4. Which type of Earth motion is responsible for seasons? _____

The Water Cycle

1. The water cycle describes the circulation of water on, above, and below Earth's surface.
2. Water vapour is the most abundant greenhouse gas in the atmosphere.
3. When the temperature increases, more water evaporates.
4. An increased amount of water vapour in the atmosphere may have two effects:
   - More solar energy may be absorbed and radiated by greenhouse gases.
   - More solar energy may be reflected back out to space and never reach Earth.

Ocean Currents

1. Convection currents in the oceans move large amounts of thermal energy all around Earth (Figure 11.2).
2. Deep ocean currents are driven by differences in the density of water, which is affected by temperature and salt content.
   - Cold and salty water sinks below warmer, less salty water.
   - Large changes in ocean water density can change direction of currents.
3. Surface currents exchange heat with the atmosphere.
   - The path of surface currents is affected by wind, Earth's rotation, and the shape of continents.
4. The **thermocline** is the transition zone that separates the cold, deep ocean waters from the Sun-warmed surface waters.

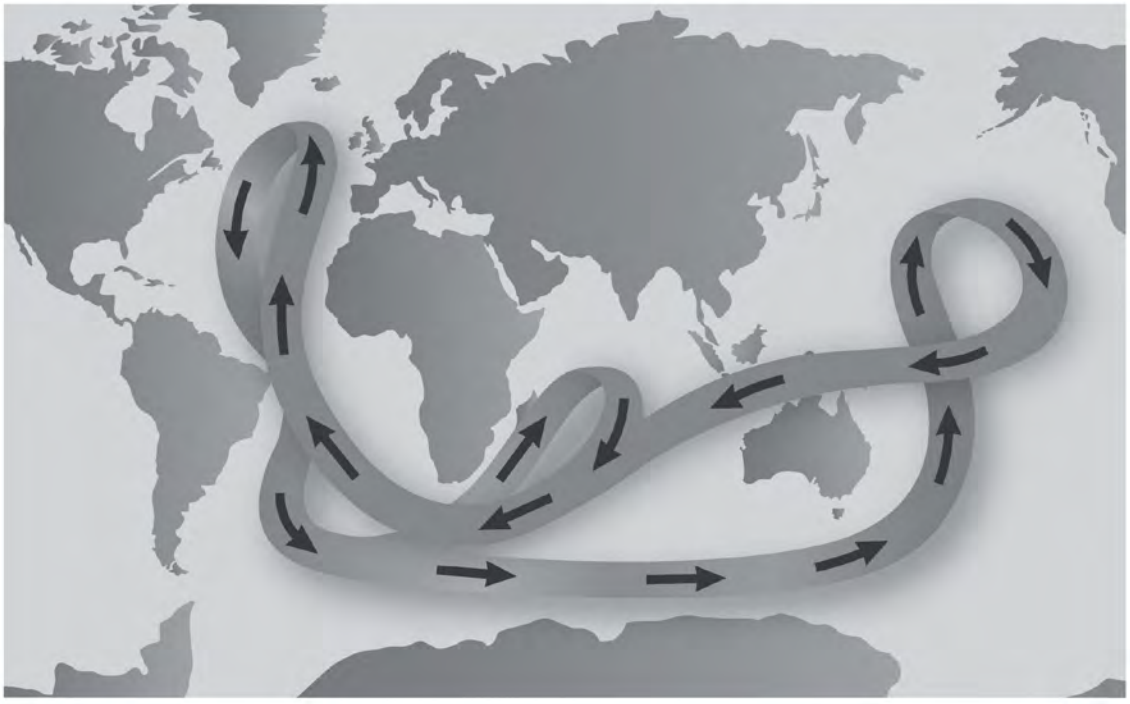


FIGURE 11.2 Deep-ocean currents form a global conveyer belt. Cold and salty water sinks below warmer less salty water, resulting in convection currents.

Quick Check

1. Which greenhouse gas is most abundant in Earth's atmosphere?

   _____

2. What two factors affect the density of ocean water?

   _____

   _____

3. What is a thermocline? _____

   _____

   _____

El Niño and La Niña

1. Sometimes, deep water rises above the thermocline to the surface in a process called upwelling.
2. A **La Niña** event is an example of upwelling that brings cooler than normal waters to the surface of the eastern Pacific Ocean.
   - Cool water at the surface of the Pacific causes warm winters in southeastern North America and cool winters in the northwest.
3. In an **El Niño** event, unusually warm water on the surface of the Pacific Ocean leads to warmer winters in the Pacific Northwest and in eastern Canada.
4. **El Niño Southern Oscillation (ENSO)** refers to phenomena of the El Niño and La Niña events and to changes in air pressure over the southern Pacific Ocean.

The Carbon Cycle

1. The carbon cycle maintains a balance of CO_2 in the atmosphere by balancing carbon sources, which release CO_2 and carbon sinks, which remove CO_2.
   - Deep oceans and mature forests store carbon.
   - Weathering of rocks, forest fires, and decaying vegetation release carbon.

Catastrophic Events

1. Large-scale disasters can quickly change atmospheric conditions.
2. Erupting volcanoes can release ash and molten rock that absorb radiation.
   - Water vapour and sulfur dioxide (changed into sulfuric acid) can reflect solar radiation back into space.
3. Meteorites, asteroids, and comets that strike Earth can cause large quantities of dust, debris and gases in the atmosphere, which reduce the amount of solar radiation that reaches Earth's surface.

Quick Check

1. How is an El Niño event different from a normal year?

   _____

   _____

2. (a) What are two examples of where carbon is stored?

   _____ _____

   (b) What are three sources that release carbon into the atmosphere?

   _____

   _____

   _____

3. How can volcanic activity cause cooling of Earth's surface? _____

   _____

   _____

4. How can a large comet strike cause cooling of Earth's surface? _____

   _____

   _____

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
Which of the following defines the term "thermocline"?	
A. the tendency of Earth to warm due to the greenhouse effect	A. This is called global warming or global climate change.
B. the boundary between high and low pressure air masses	B. This is called a front.
C. the upwelling of cooler-than-normal waters in the eastern Pacific Ocean	C. This is called a La Niña event.
D. the boundary between deep cool ocean water and the warmer layer above it	D. This answer is correct.

➜ Why was this question asked?

This question was asked to determine if you know terms related to ocean currents.

➜ Where can I get extra practice on this type of question?

- Use pages 471 to 473 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
What causes the seasons?	
A. Earth's orbit is not a perfect circle. Summer is when Earth is closest to the Sun, and winter is when it is farthest.	A. While it is true that the orbit is not a circle, the difference in radiation received by Earth between its closest and farthest approach to the Sun is tiny and does not cause the seasons.
B. The Sun's radiation is not constant. Summer is when the Sun is releasing more energy, and winter is when it is releasing less energy.	B. While the Sun's radiation is not constant, these slight changes do not cause the seasons. Over thousands or millions of years, they might cause climate changes.
C. Earth's rotation is tilted relative to its orbit around the Sun. When Earth spins clockwise it is summer, and when Earth spins counter-clockwise it is winter.	C. Earth does not stop and change the direction of its rotation.
D. Earth's rotation is tilted relative to its orbit around the Sun. Where the axis of rotation points towards the Sun it is summer, and where the axis points away from the Sun it is winter.	D. This answer is correct. It implies that, when it is summer in the northern hemisphere, it must be winter in the southern hemisphere.

➜ Why was this question asked?

This question was asked to determine if you can explain which of Earth's motions are responsible for the seasons.

➜ Where can I get extra practice on this type of question?

- Use pages 468 to 470 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 11.1

Climate change occurs through natural processes and human activities: Natural Causes of Climate Change

Circle the letter of the best answer.

1. Which of the following types of evidence might a paleoclimatologist use to study climate change?

I	ice cores from glaciers
II	ocean wave patterns
III	tree-trunk ring studies
IV	plant fossils

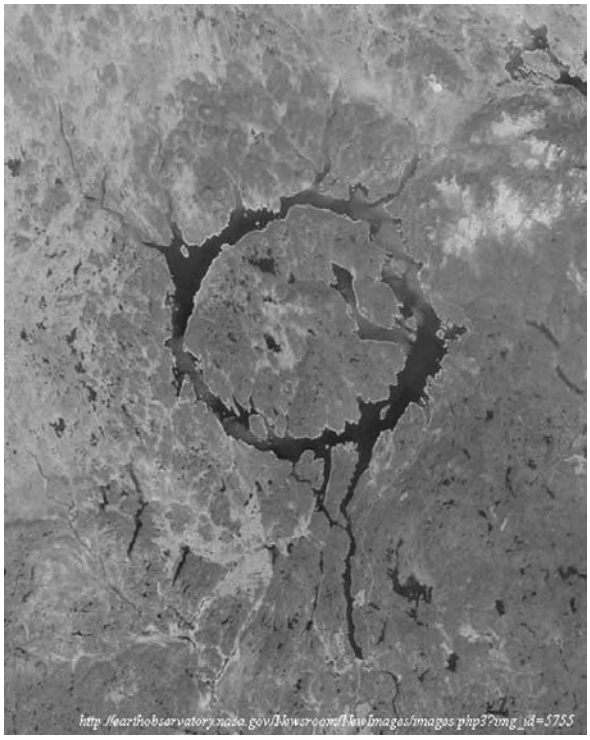
   A. I only
   B. I and III only
   C. I, III, and IV only
   D. I, II, III, and IV

2. Which of the following best defines the term "climate"?
   A. the temperature readings for the past 30 years or more
   B. the specific weather patterns for a local region or city
   C. the weather patterns that are occurring right now
   D. the average conditions of the atmosphere for a large region for the past 30 years or more

3. Earth's temperature is regulated by the greenhouse effect. What statement best describes how the greenhouse effect works?
   A. Greenhouse gases act like a greenhouse, which absorbs and retains solar energy, thereby increasing Earth's temperature.
   B. The Sun's radiation is amplified by Earth's oceans.
   C. The greenhouse effect is caused by human activity.
   D. Greenhouse gases create thermal radiation.

4. Which of the following events may have been catastrophic enough to have caused mass extinctions in the past?
   A. a volcanic eruption
   B. a meteorite strike
   C. an earthquake
   D. a tsunami

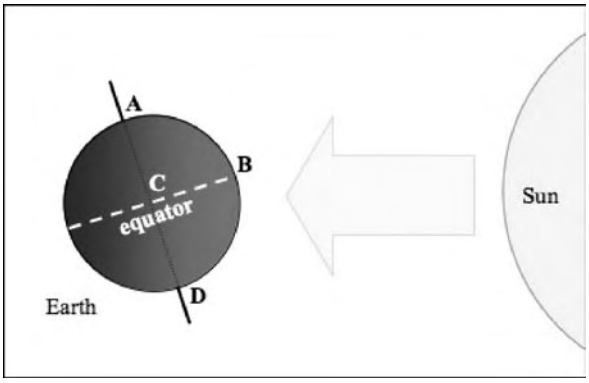
Use the following satellite photograph to answer question 5.



5. The picture above is a NASA photo of Lake Manicouagan, a scar left in northern Quebec. What is the most likely cause of this massive scar on Earth?
   A. a glacier
   B. a volcano
   C. an asteroid
   D. an earthquake

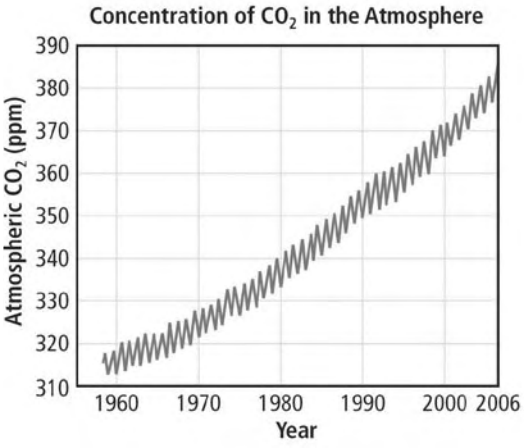
6. What affect does the phenomenon known as El Niño have on coastal British Columbia winters?
   A. cooler than usual
   B. warmer than usual
   C. no change
   D. more extreme weather events

Use the following diagram to answer question 7.



7. What season would people be experiencing at A?
   A. spring
   B. summer
   C. fall
   D. winter

Use the following graph to answer question 8.



8. What is the result of the changes indicated in the graph?
   A. stronger deep ocean currents
   B. increased deforestation
   C. global warming
   D. an El Niño event

9. Carbon dioxide is kept in balance by the natural patterns of the carbon cycle. Which of the following would **not** be considered a carbon sink or store?
   A. deep oceans
   B. precipitation
   C. dead vegetation
   D. new growth forest

10. How can a large comet collision impact on Earth result in global climate change?
   A. Debris scatters into the atmosphere, reflecting sunlight and causing global cooling.
   B. Debris scatters into the atmosphere, capturing sunlight and causing global warming.
   C. Heat from the impact causes global warming.
   D. Cooling from the ice in the comet causes global cooling.

11.2 Human Activity and Climate Change

I. Summary of Key Points

- Climate change refers to changes in long-term weather patterns in certain regions.
- Global warming, an increase in Earth's average global temperature, is one aspect of climate change.
- The current increase in global temperature is caused by an increase in greenhouse gas emissions, especially carbon dioxide, from the burning of fossil fuels and other human activities.
- Various regions of Earth are expected to undergo changes in temperature, precipitation patterns, and the amount of ice.
- Climate change is expected to affect society, economies, and the environment.

II. Study Notes

Global Warming

1. **Climate change** is the change in long-term weather patterns in certain regions.
   - These changes can affect the flow of thermal energy around Earth.
2. Global warming refers to an increase in global average temperature.
   - The average global temperature increased by about 0.74°C from 1906 to 2005.
   - The effects of global warming are unknown and are the subject of debate.
     - Some scientists believe that human-caused climate change may happen too quickly for the biosphere to adapt.

The Enhanced Greenhouse Effect

1. The enhanced greenhouse effect is the increased capacity of the atmosphere to absorb and emit thermal energy because of an increase in greenhouse gases (Figure 11.3).
   - Water vapour is an important greenhouse gas, contributing about 65 percent of the greenhouse effect, but human activities have very little direct effect on the amount of water vapour in the atmosphere.
   - Carbon dioxide contributes about 25 percent of the greenhouse effect.
   - Other gases, such as methane, nitrous oxide, CFCs, and surface ozone together contribute about 10 percent of the greenhouse effect.

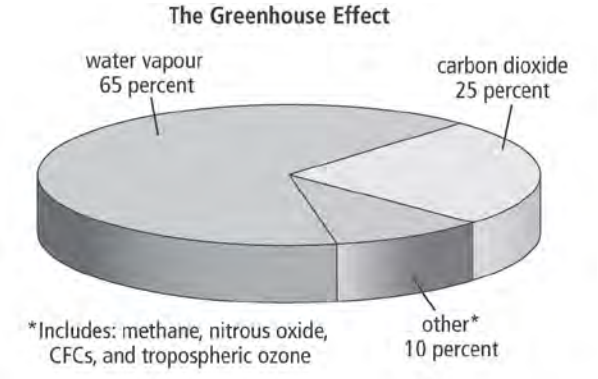


FIGURE 11.3 The approximate contribution of greenhouse gases to the greenhouse effect

2. More greenhouse gases in the atmosphere = increase of natural greenhouse effect.
3. Global warming potential (GWP) describes the ability of a substance to warm the atmosphere by absorbing and emitting thermal energy (Table 11.1 on next page).

TABLE 11.1 Greenhouse Gases and Global Warming Potential

Greenhouse Gas	Chemical Formula	Atmospheric Lifetime (y)	Source from Human Activity	Global Warming Potential
carbon dioxide	CO_2	variable	– combustion of fossil fuels – deforestation	1
methane	CH_4	about 12	– processing of fossil fuels – livestock, agriculture – waste dumps – rice paddies	25
nitrous oxide	N_2O	114	– production of chemical fertilizers – burning waste – industrial processes	298
chlorofluorocarbons (CFCs)	various	45	– liquid coolants – refrigeration – air conditioning	4750–5310

Quick Check

1. Compare the global warming potential of equal amounts of CFCs and CO_2.

   _____

   _____

2. After water vapour, which greenhouse gas is the most responsible for the greenhouse effect?

   _____

3. What is the enhanced greenhouse effect? _____

   _____

   _____

Ozone

1. Chlorofluorocarbons (CFCs) were commonly used in spray cans, such as hairspray and spray paint, until it was discovered that CFCs release chlorine atoms into the atmosphere that break apart ozone (O_3) molecules.
   - An **aerosol** is a suspension of fine solid or liquid particles in a gas.
2. The **ozone layer** is a layer in the stratosphere that filters out harmful ultraviolet radiation from the Sun.
   - Holes in the ozone layer could potentially increase global warming by allowing more solar radiation to reach Earth's surface.
3. At lower altitudes, ozone is a very powerful greenhouse gas.
   - Surface ozone comes from solar radiation reacting with pollution from the burning of fossil fuels, and is released from photocopiers and certain air purifiers.

Albedo and Climate

1. Albedo describes the amount of radiation reflected by a surface.
   - Snow-covered areas and deserts have high albedos; many forests and soils have low albedos.
2. If large expanses of Arctic sea ice were to melt, the albedo in the Arctic would drop and the region would absorb more solar radiation.
3. Boreal forests have a low albedo, so they absorb solar radiation.
   - Deforestation increases albedo, causing more solar radiation to be reflected back into space.
4. It is not known how changes in albedo will affect average global temperature.

Quick Check

1. What is the beneficial effect of ozone in the stratosphere? _____

   _____
2. What is the harmful effect of ozone near the surface of Earth? _____

   _____
3. Snow-covered areas are said to have a high albedo. What does this mean? _____

   _____
4. How does the melting of sea ice increase the amount of sunlight that Earth absorbs? _____

   _____

The Role of Science in Understanding Climate Change

1. General Circulation Models (GCMs) are computer models used to study climate, to forecast weather, to analyze climate, and to predict climate change.
   - GCMs take into account changes in greenhouse gases, albedo, ocean currents, winds and surface temperatures, and also take into account the properties of fluids, chemical reactions, and how organisms affect their environment.

The Role of International Cooperation in Climate Change

1. The United Nations (UNEP) and the World Meteorological Organization (WMO) created the Intergovernmental Panel on Climate Change (IPCC) to address global concerns about climate change and global warming.
   - The IPCC examines possible climate change, highlights the cause, and suggests solutions.

Global Impacts of Climate Change

1. Current climate change models predict that temperatures will increase more in arctic regions than in equatorial regions and more on land than in the oceans.
2. Potential global effects of climate change include rising sea levels, water conflicts, greater disease risk, increased severity and frequency of tropical storms, decreased crop yields, increased deforestation, and changes in fisheries.

Impacts of Climate Change on Canada and **Impacts of Climate Change on British Columbia**

1. Climate change affects weather patterns, such as winter and summer temperatures and the amount and location of rainfall.
2. Parts of Canada have had average temperature increases of 0.5°C to 1.5°C during the last 25 years.
   - The ice cover in the Arctic Ocean is rapidly shrinking, making it difficult for polar bears to hunt.
   - Some areas of permafrost are melting.
     - **Permafrost** is ground that usually remains frozen year-round.
   - Growing seasons are getting longer, and more precipitation is occurring.
3. In the future in British Columbia:
   - There could be heavier spring rains and flooding and more frequent and longer lasting droughts.
   - Sea levels could rise.
   - Fisheries could be negatively affected.
   - Forests may benefit from longer growing seasons, but there could also be increased forest fires and more insects that harm trees.
   - An increase in CO_2 dissolved in the ocean would make ocean water more acidic and could result in the loss of some species.

Uncertainty and Decision

1. Predictions about climate change cannot be certain.
2. Our response to climate change affects society, the economy, and the environment.
   - People in developed countries are concerned about the costs of implementing changes.
   - People in developing countries are reluctant to slow their economic growth.
3. The United Nations suggests that we should not postpone cost-effective measures to prevent serious environmental damage just because of a lack of scientific certainty about climate change.

An Action Plan for the Global Community, and Canada's Response to Climate Change

1. Decreasing overall greenhouse gas emissions requires global cooperation.
2. Relatively small changes, such as the following, could positively affect the climate in Canada (see Figure 11.4 for sources of greenhouse gas emissions in Canada).
   - Reduce vehicle greenhouse gas emissions.
   - Reduce industrial greenhouse gas emissions.
   - Increase use of energy-efficient products.
   - Improve indoor air quality.
   - Improve fertilizer use.
   - Promote worldwide planting of trees.
   - Promote recycling, composting, and minimizing waste.

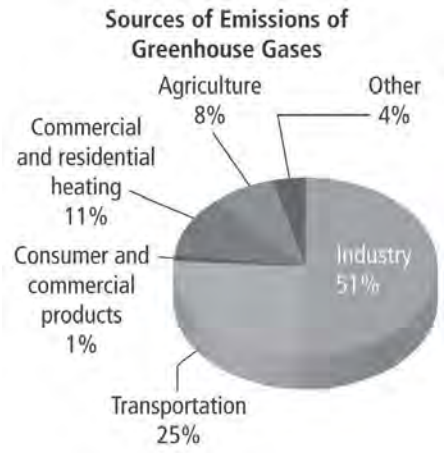


FIGURE 11.4 Sources of emissions of greenhouse gases in Canada

Quick Check

1. List six potential negative global effects of climate change.

_____ _____ _____

_____ _____ _____

2. List six ways Canadians could positively affect climate in Canada.

_____

_____

_____

_____

_____

_____

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
What negative effects to British Columbia's environment are likely to result from global climate change? I — hotter, drier summers II — wetter springs III — increased insect infestations	
A. I only	A. Increased temperatures will mean hotter, drier summers.
B. I and III only	B. Since winters will not be as cold, insect pests will thrive.
C. II only	C. Warmer temperatures do not just mean drier weather all year. Rather, it means more extreme weather. In B.C., rainy seasons are expected to have increased precipitation.
D. I, II, and III	D. This answer is correct.

➜ Why was this question asked?

This question was asked to determine if you understand important environmental effects due to climate change.

➜ Where can I get extra practice on this type of question?

- Use pages 488 to 496 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
What gas is the major contributor to the enhanced greenhouse effect?	
A. water vapour	A. Water vapour does contribute the majority of warming due to the greenhouse effect, but it is not responsible for the increased warming due to the enhanced greenhouse effect.
B. carbon dioxide	B. This answer is correct. Carbon dioxide causes most of the heating because human activity has increased its concentration so dramatically.
C. ozone	C. Ozone is a powerful greenhouse gas, but its concentrations are much lower than carbon dioxide.
D. chlorofluorocarbons	D. Chlorofluorocarbons are powerful greenhouse gases, but their concentrations are much lower than carbon dioxide.

➜ Why was this question asked?

This question was asked to determine if you can understand the contribution of greenhouse gases to the enhanced greenhouse effect.

➜ Where can I get extra practice on this type of question?

- Use pages 484 to 486 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

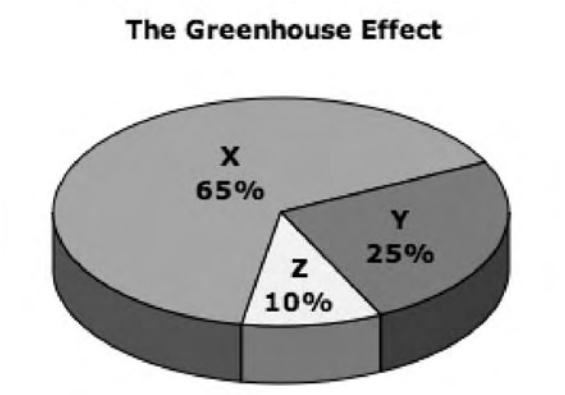
Section 11.2

Climate change occurs through natural processes and human activities: Human Activity and Climate Change

Circle the letter of the best answer.

1. What is the basic difference between climate change and global warming?
   A. Climate change refers to the long-term change of the whole planet, and global warming refers to the increase in regional temperature.
   B. Climate change refers to the average temperature change on Earth, and global warming refers to the long-term change in temperature for a region.
   C. Climate change refers to the long-term change in weather patterns in a region, and global warming refers to the increase in the average global temperature.
   D. Climate change refers to the long-term change in temperature in a region, and global warming refers to the increase in global weather change.

Use the diagram below to answer question 2.



2. What greenhouse gas is represented by the X in the above diagram?
   A. ozone
   B. water vapour
   C. nitrous oxide
   D. carbon dioxide

3. Which of the following chemicals linked to global warming has the highest global warming potential (GWP)?
   A. methane, CH_4
   B. nitrous oxide, N_2O
   C. carbon dioxide, CO_2
   D. chlorofluorocarbons, CFCs

4. Scientists have discovered evidence that Earth has gone through global warming and cooling before. Why are people concerned about it this time?
   A. The demand on air conditioning will increase.
   B. Climate change may happen too quickly for the biosphere to adapt.
   C. All scientists agree that humans are responsible for global warming.
   D. Most scientists think that global warming will have no effect for at least 100 years.

5. This is an image of non-vertical or "drunken" trees in the subarctic. Which global phenomenon is the most likely cause of these crooked trees?
   A. melting permafrost
   B. increased precipitation
   C. a hole in the ozone layer
   D. increased insect infestation

6. Which has the lowest albedo?

   A. clouds
   B. glaciers
   C. forests
   D. oceans

7. Why is ozone important to the environment?

   A. It is a greenhouse gas at low altitudes.
   B. It screens out ultraviolet light at high altitudes.
   C. It breaks apart to form oxygen gas.
   D. It is a poison.

8. What effect does melting polar ice in the Arctic have on Canadian polar bears?

   A. Their ability to hunt is reduced.
   B. They migrate south earlier in the year.
   C. Their body temperatures are increasing.
   D. There is an increased number of seals to feed on.

9. Which of the following is **not** a strategy to address climate change?

   A. Introduce alternative fuels.
   B. Find new sources of fossil fuels.
   C. Promote worldwide reforestation.
   D. Research and develop renewable energy sources.

10. Which of the following statements about albedo and its effect on global warming is true?

    A. As the snow and polar icecaps grow, a decrease in albedo will result and more solar energy will be reflected from the ice.
    B. As the snow and the polar icecaps melt, a decrease in albedo will result from the oceans reflecting more solar energy.
    C. As snow and polar icecaps melt, a decrease in albedo will result in the oceans absorbing more solar energy.
    D. As the snow and polar icecaps grow, an increase in albedo will result in the ice absorbing more radiation.

Chapter 12 Thermal energy transfer drives plate tectonics.

12.1 Evidence for Continental Drift

I. Summary of Key Points

- Various pieces of evidence indicate that the continents were once joined but later drifted to their current positions.
  - The continental shelves of the continents can be aligned.
  - Regions of some continents that are far apart have similar rocks, mountain ranges, fossils, and patterns of paleoglaciation.
- The process of sea floor spreading provides a mechanism for continental drift.
- The continents are attached to huge slabs of rock, known as tectonic plates.
- When the tectonic plates move across Earth's surface, they carry the continents with them.

II. Study Notes

The Jigsaw Puzzle Fit

1. The **continental drift theory** is a theory put forward by Alfred Wegener in the early 20th century that proposed that continents moved around on Earth's surface and were at one time joined together.
2. Wegener suggested that millions of years ago the continents were joined together as a **supercontinent**, which he called Pangaea, meaning "all Earth."
   - The shape of the continents on a world map suggests that they might fit together like jigsaw pieces.
   - The fit is even better when the continental shelves surrounding the continents are included.
     - A continental shelf is a shallow, undersea plain stretching off the coast of a continent.
3. See the Geological Time chart on page 7 of your Data Pages for information on geological time, models of how Pangaea may have formed, and models of how the continents may have moved into their present positions.
   - Earth scientists and geologists use the **geological time** scale to describe the timing of and relationships between events in Earth's past.

Matching Geological Structures and Rocks, Matching Fossils, and **Climatic Evidence for Continental Drift**

1. Other evidence supported Wegener's theory of continental drift.
   - There were matching geologic features, such as mountain ranges and rocks, on different continents.
   - There were matching fossils, such as *Mesosaurus*, on different continents representing species that could not cross oceans.
   - There was evidence of different climates in the past, such as coal deposits in Antarctica, which is now too cold to support plant life, and evidence of glaciers in parts of Africa, where it is now too warm for glaciers to form.
     - **Paleoglaciation** is a term describing past periods of extensive glaciations that covered most of the continents.

Quick Check

1. What did Wegener notice about the shapes of continents that led him to suggest that continents were able to move? _____

   _____

2. List three forms of evidence besides continent shape that gave support to the idea of continental drift.

   _____

   _____

   _____

How Can Continents Move? and **A Possible Mechanism**

1. Wegener's evidence for continental drift did not explain how entire continents could change locations, so his theory was rejected by scientists of his time.
2. Wegener and the other scientists of his time did not know that Earth's surface is broken into large, rigid, movable slabs of rock called **tectonic plates** that slide over a layer of partly molten rock.
3. New scientific equipment developed since the 1940s has allowed scientists to gather evidence from the sea floor.
   Evidence from mapping the sea floor: When explorers began to map the ocean floor, they discovered undersea mountain ranges.
   - A **mountain range** is a chain of mountains separated from other mountains or surrounded by lowlands.
   - They discovered a **mid-ocean ridge**, a mountain range running north to south down the length of the Atlantic Ocean, which they named the Mid-Atlantic Ridge.

   Evidence from ocean rock and sediments: Rocks taken from the Mid-Atlantic Ridge were younger than other ocean rocks.
   - Sediments along the Mid-Atlantic Ridge became thicker farther away from the ridge.

   Evidence from paleomagnetism: The direction of Earth's **magnetic polarity** can experience a **magnetic reversal** over thousands of years so that the magnetic north pole becomes the magnetic south pole and vice versa.
   - Paleomagnetism is the study of the magnetic properties of ancient rocks.
   - Using a **magnetometer**, a device that detects variations in magnetic fields, researchers discovered that the rocks on either side of the Mid-Atlantic Ridge had a pattern of stripes in the direction that iron-containing rocks pointed (Figure 12.1).
   - This evidence indicated that some rocks formed when Earth's magnetic polarity was normal and some formed when the polarity was reversed.

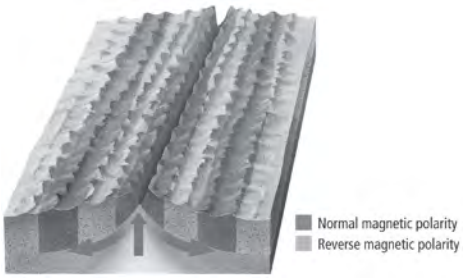


FIGURE 12.1 Over time, the orientation of Earth's magnetic field has reversed many times. Periods of normal polarity and reverse polarity can be detected by measuring the magnetic fields of rocks on the sea floor.

Sea Floor Spreading

1. In 1960, American geologist Harry Hess proposed that magma rises from below Earth's surface, then cools and hardens when it breaks through the surface at a geologic hot spot or a mid-ocean ridge (also called a **spreading ridge**), forming new sea floor.
   - A geologic **hot spot** is the location of excess radioactivity, causing magma to rise to Earth's surface.
     - The Hawaiian Islands formed as a tectonic plate passed over a hot spot and magma rose up from under Earth's surface.
   - Convection currents deep under Earth's surface may cause new magma to rise and continuously push the old rock aside in a process called **sea floor spreading**.
2. In the mid-1960s, Canadian geologist J. Tuzo Wilson combined the concepts of sea floor spreading and paleomagnetism to explain continental drift, laying the groundwork for the plate tectonic theory.
   - The **plate tectonic theory** states that Earth's surface is broken into large plates that move apart and then rejoin, sliding over the semi-fluid rock below.

Quick Check

1. Why were Wegener's ideas about continental drift originally rejected? _____

   _____

   _____

2. Explain the implications of evidence from each of the following areas.

   (a) mapping the sea floor _____

   _____

   _____

   (b) analyzing ocean rock and sediments _____

   _____

   _____

   _____

   (c) paleomagnetism _____

   _____

   _____

3. How did the Hawaiian Islands form? _____

   _____

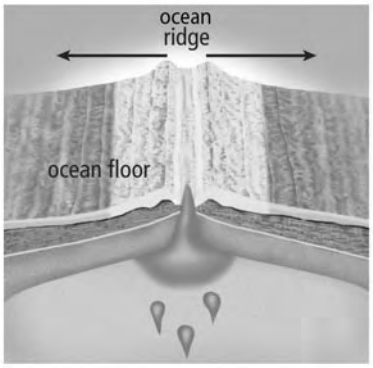
   _____

4. What does the theory of plate tectonics state? _____

   _____

   _____

III. Sample Exam Questions Explained

The Question	Why It Is Right/Why It Is Wrong
 Which feature is shown in the diagram?	
A. hot spot	A. A hot spot involves a cylinder of rising magma rather than a long ridge.
B. sea floor spreading	B. This answer is correct. Rising magma due to convection currents breaks through at the ridge and causes the ocean floor on either side to spread apart.
C. paleoglaciation	C. This is the result of the marking that glaciers make on rock formations.
D. jigsaw fit	D. This is the idea that continents are shaped in such a way that they can fit together.

➜ Why was this question asked?

This question was asked to determine if you understand the mechanism for sea floor spreading.

➜ Where can I get extra practice on this type of question?

- Use pages 510 to 513 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
Refer to the Geological Time chart on page 7 of your Data Pages. How long ago did Pangaea exist?	
A. about 6000 years ago	A. Look down the column "Lithosphere" until you see the labels "Pangaea breaking apart" and "Pangaea forming." Read left across the chart to find the time.
B. about 250 000 years ago	B. You many have misread the chart. The chart gives the time as 250 Ma which means 250 million years.
C. about 250 000 000 years ago	C. This answer is correct
D. about 4.6 billion years ago	D. This is the age of Earth.

➜ Why was this question asked?

This question was asked to determine if you can use the Geological Time chart in your Data Pages.

➜ Where can I get extra practice on this type of question?

- Use pages 507 and 508 in *BC Science 10* and page 7 of your Data Pages.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 12.1

Thermal energy transfer drives plate tectonics: Evidence for Continental Drift

Circle the letter of the best answer.

1. Which of the following observations represent evidence provided by Wegener to support his theory of continental drift?

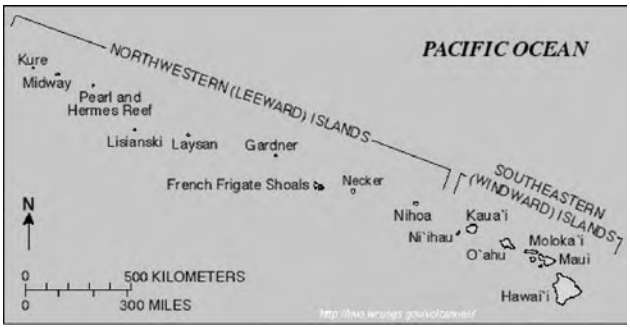
I	the "jigsaw fit" of the continents
II	matching geological structures and rocks on different continents
III	matching fossils on different continents
IV	paleoglaciation
V	sea floor spreading

   A. I, II, III, and IV only
   B. I, II, III, IV, and V
   C. II and III only
   D. II, III, and IV only

2. Which of the following is **not** evidence of tectonic plate movement?
   A. The pattern of the magnetic striping is the same on both sides of the Mid-Atlantic Ridge.
   B. Rock samples taken near the Mid-Atlantic Ridge are much younger than those taken near the west coast of Africa and the east coast of South America.
   C. Stripes of rock from the Mid-Atlantic Ridge have alternating magnetic polarities.
   D. There is more sediment along the continental shelf than on the ocean floor.

3. Which of the following statements best defines Pangaea?
   A. an underwater ocean range
   B. a supercontinent that used to exist on Earth
   C. the fossil that represents evidence for continental drift
   D. the weak spot in the plate that created the Hawaiian Islands

Use the following map to answer question 4.



4. The Hawaiian Islands are continuing to form as a tectonic plate passes over a stationary hot spot. The only island that still has an active volcano is the big island of Hawaii. What direction is the plate travelling that is responsible for the formation of the Hawaiian Islands?
   A. southeast
   B. northeast
   C. northwest
   D. southwest

5. Which of the following represents why the sea floor is relatively "young" compared to the continents?

I	The sea floor is continually being generated at mid-ocean ridges.
II	Earth was once covered by a massive continent.
III	The sea floor is continually being destroyed.

   A. I only
   B. I and II only
   C. I and III only
   D. I, II, and III

6. Why was Wegener's theory of continental drift difficult for the scientific community to accept when the theory was proposed?

   A. Paleoglaciation points to common glacial evidence on many continents.
   B. Wegener could not explain what could cause the continents to move.
   C. Unique geological features can be found on opposing continents.
   D. The shapes of continents fit together like a jigsaw puzzle.

7. Which of the following is **not** true of the evidence of sea floor spreading provided by magnetic striping?

   A. Earth is like a large bar magnet and has two poles.
   B. Earth's magnetic poles reverse over hundreds of thousands of years.
   C. Rocks with magnetic striping, alternating bands of normal and reverse polarity, surround ocean ridges.
   D. The pattern of magnetic striping is different in rocks on either side of an ocean ridge.

8. What force pushes magma to the surface at ocean ridges and ultimately drives the movement of tectonic plates?

   A. continental drift
   B. earthquakes
   C. volcanic eruptions caused by a hot spot
   D. convection currents in the magma

9. What is a tectonic plate?

   A. a large, flexible slab of rock
   B. a large, rigid slab of rock
   C. a lava flow
   D. a continent

10. What evidence was discovered that helped to explain how continents are capable of moving?

    A. fossil remains that matched across large oceanic plates
    B. tropical plant fossils in non-tropical areas
    C. a solid crust on top of a fluid mantle
    D. magnetic striping of the sea floor

12.2 Features of Plate Tectonics

I. Summary of Key Points

- Earth has distinct layers.
- The asthenosphere is the partly molten layer of Earth located beneath the lithosphere.
- Convection currents from the asthenosphere push magma to Earth's surface, causing tectonic plates to move and sometimes converge.
- When tectonic plates converge, one plate may slide beneath the other or the edges of the plates may crumple, forming mountains.
- Tectonic plates can also diverge, or spread apart, forming rifts on land and ridges in the oceans.
- Tectonic plates may begin to slide past one another at a transform boundary, resulting in the build-up of pressure, which may be released as an earthquake.
- Volcanoes occur at tectonic plate boundaries or over geologic hot spots, where magma is coming up through Earth's crust.

II. Study Notes

Tectonic Plates and **A Cross-Section of Earth**

1. Earth is over 1200 km thick and has four distinct layers (Figure 12.2).
   - **Crust**: outer solid rock layer
     - **Continental crust** is made from a less dense type of rock called granite.
     - **Oceanic crust** is made from a dense rock called basalt.
   - **Mantle**: thickest layer, mostly solid except for upper mantle being able to flow like "thick toothpaste"
   - **Outer core**: liquid iron and nickel
   - **Inner core**: mostly iron, the tremendous pressure keeps it solid.
     - Heat from Earth's core helps produce convection currents and hot-spot activity.
2. A cross-section model of Earth is shown below.
   - A **cross-section** represents a slice of an object and shows its interior, whereas a map view shows only the object's surface.

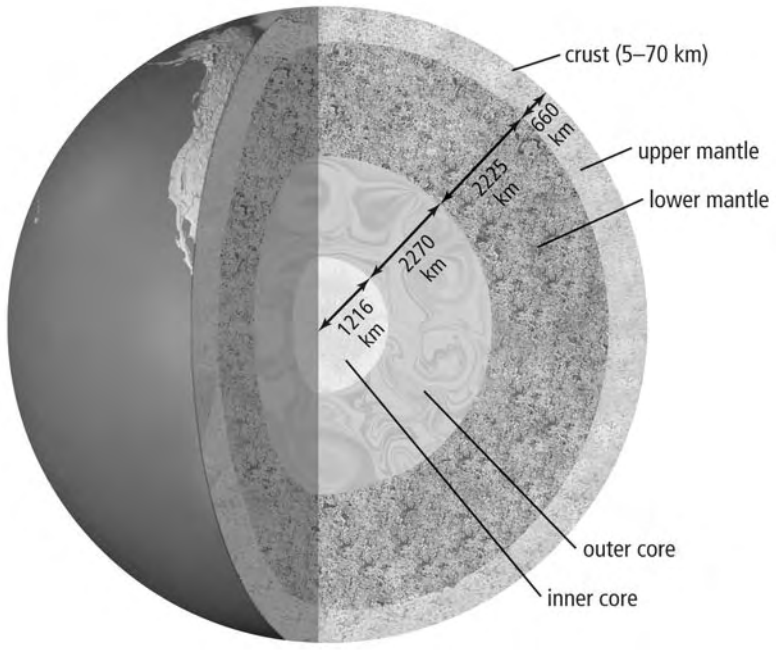


FIGURE 12.2 A cross-section of Earth

Plate Motion

1. Tectonic plates make up the lithosphere, which floats on the asthenosphere
   - The **lithosphere** is the crust and upper portion of the mantle.
   - The **asthenosphere** is the molten layer of the upper mantle.
2. There are about 12 major tectonic plates and many smaller ones.
   - Tectonic plates are all moving at the same time.
3. **Mantle convection** is thermal energy transfer in the mantle where hot, light magma rises and cold, dense lithospheric plate material sinks.
   - **Density** is the amount of mass contained in a given volume.
   - Heat to keep the asthenosphere molten comes from radioactive elements.
   - A **mantle plume** is an upwelling of extremely hot rock within Earth's mantle that forms hot spots**.**
4. Continents, attached to the tectonic plates, float in the magma of the asthenosphere.
5. Rising magma can reach the surface at spreading ridges (in the oceans) or **rift valleys** (on land).
   - The magma cools when it reaches the surface, solidifies, and is pushed aside as new magma pushes from below.
   - In a process called **ridge push,** the spreading mid-ocean ridge pushes the rest of the tectonic plate it is on away from the ridge.
6. **Subduction** is the action of one tectonic plate pushing below another tectonic plate (Figure 12.3).
   - A more dense oceanic plate subducts under a lighter continental plate.
   - The dense, subducting plate material pulls the rest of the attached plate toward the subduction zone and down into the mantle, a process called **slab pull**.
7. Along with convection currents and ridge push, slab pull helps keep tectonic plates in motion.
8. A **plate boundary** is the location where two plates meet and move relative to each other.

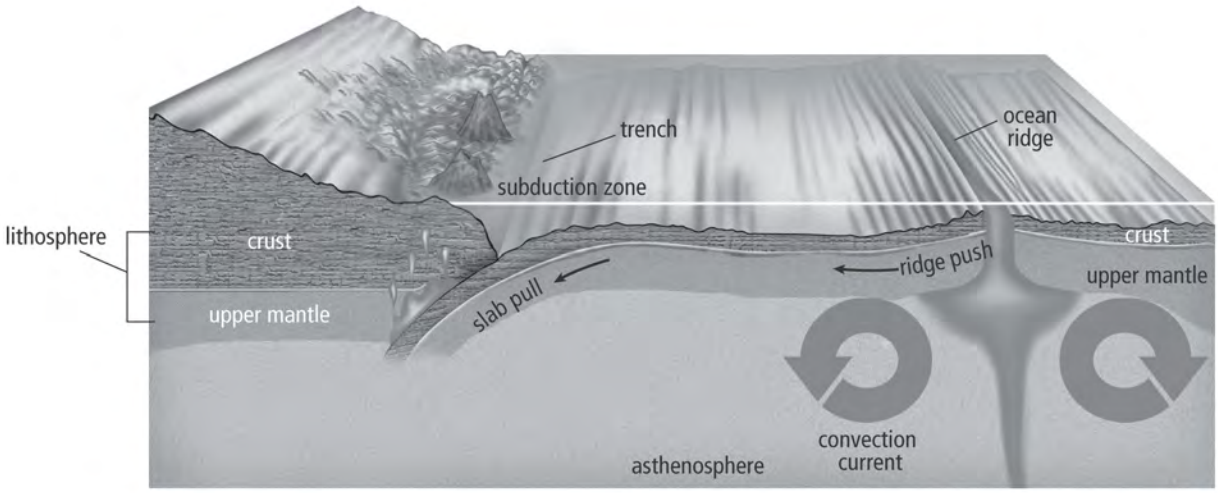


FIGURE 12.3 Thermal energy from inside Earth, gravity, and tectonic plate interactions affect the movement of tectonic plates.

Quick Check

1. Name the four layers of Earth, in order from the inside out.

   (a) _____ (b) _____

   (c) _____ (d) _____

2. What is the difference between the densities of oceanic crust and continental crust? _____

   _____

3. What is the source of energy for convection currents and hot-spot activity in Earth's mantle?

   _____

4. In terms of the crust and the mantle, describe:

   (a) the lithosphere _____

   (b) the asthenosphere _____

5. What is a mantle plume? _____

   _____

6. How does a rift valley form? _____

   _____

7. What happens in subduction? _____

   _____

Plate Interactions

Refer to your Data Pages, page 11, for the Tectonic Plate Boundaries Map. Each of the following plate boundaries and their movements are shown on the map. Notice the different symbols used to show each type of boundary on the map.

1. **Divergent** plate boundaries are areas where tectonic plates are spreading apart.
   - Ocean ridges such as the Mid-Atlantic Ridge are examples of divergent plate boundaries.
   - Diverging plates at the East African Rift are slowly breaking Africa into pieces.
2. **Convergent** plate boundaries are areas where tectonic plates collide.
   - A **subduction zone** is a zone representing a convergent plate boundary, where one tectonic plate subducts beneath and is destroyed by the other overriding tectonic plate.
     – Large earthquakes and volcanoes are found in subduction zones.
   - A **trench** is a long narrow depression in the ocean floor that marks a convergent plate boundary and is part of a subduction zone.

A. Oceanic-Continental Plate Convergence

- The oceanic plate subducts under the continental plate, forming a trench (Figure 12.4).
- Cone-shaped volcanoes can form from magma seeping to the surface.
  - A **volcano** is an opening in Earth's surface that, when active, spews out gases, chunks of rock, and melted rock.
  - A **volcanic belt** is a long chain of volcanoes.
  - The volcanic belt of the Pacific Northwest has formed as a result of the oceanic-continental convergence between Juan de Fuca Plate (oceanic) and the North American Plate (continental). See Data Pages, page 10, Map of the Pacific Coast of North America.
- Mountain ranges like the Coast Mountain range also form from the convergence.
- Earthquakes can occur when slab pull, ridge push, and subduction stall.

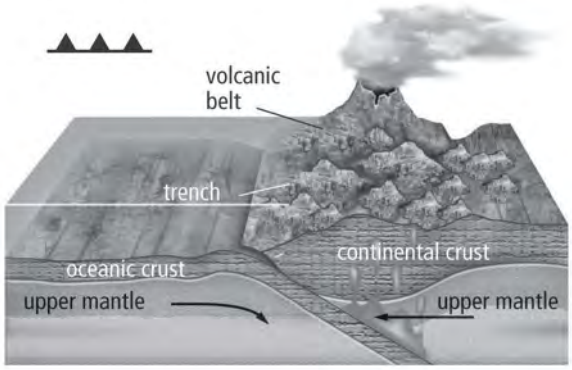


FIGURE 12.4 The convergence of an oceanic and a continental plate produced the Coast Mountains of British Columbia.

B. Oceanic-Oceanic Plate Convergence

- The cooler, denser plate subducts under the warmer, less dense plate (Figure 12.5).
- Convergence may produce a **volcanic island arc**, which is a long chain of volcanic islands, such as those found in Japan, Indonesia, and Alaska's Aleutian islands.

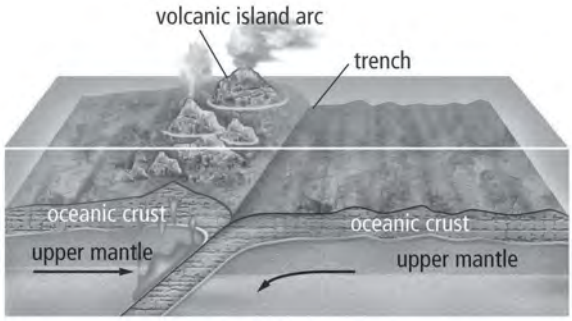


FIGURE 12.5 The convergence of two oceanic plates can produce a volcanic island arc, such as the Aleutian Islands of Alaska, in the United States.

C. Continental-Continental Plate Convergence

- Since both plates are continental plates, their densities are similar.
- As they collide, their edges fold and crumple, forming mountain ranges (Figure 12.6).
- The Himalayas are the world's youngest (and tallest) mountain range and are still growing taller today.

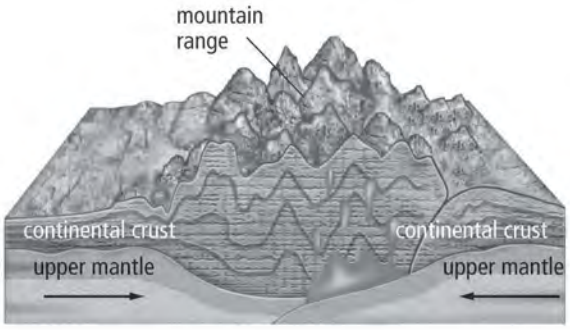


FIGURE 12.6 The convergence of two continental plates is gradually forcing the Himalayas higher.

3. **Transform** plate boundaries are areas where tectonic plates slide horizontally past each other (Figure 12.7).
   - Transform plate boundaries are usually are found near ocean ridges but may also be found on land, such as the San Andreas Fault in California.
   - Since rock slides past rock, no mountains or volcanoes form, but earthquakes and faults may result.
     - A **fault** is a break or fracture in rock layers due to movement on either side.
     - A **transform fault** is a fracture zone between two offset segments of a mid-ocean ridge.

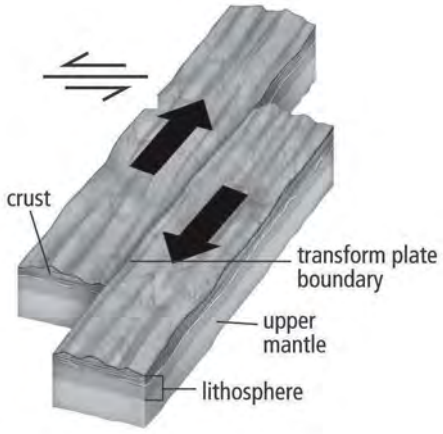


FIGURE 12.7 Transform faults can occur when tectonic plates move alongside one another.

Quick Check

1. List three kinds of plate interactions. _____

   _____ _____

2. Identify the geographical features that are typical of

   (a) two oceanic plates converging _____

   _____

   (b) an oceanic plate and a continental plate converging _____

   _____

   (c) two continental plates converging _____

   _____

   (d) two continental plates diverging _____

   _____

   (e) two oceanic plates diverging _____

   _____

3. What is the relative motion that occurs between two plates that meet at a transform boundary?

   _____

Earthquakes

1. An **earthquake** is a shaking of the ground as the result of a sudden release of energy in Earth's crust.
   - Earthquakes often form as a result of friction between moving tectonic plates that works against convection currents and results in the build-up of pressure.
2. About 80 percent of earthquakes occur in a ring bordering the Pacific Ocean.
   - The Juan de Fuca convergent plate boundary west of Vancouver Island has many earthquakes.
3. The **focus** of an earthquake is where the pressure is finally released.
   - The **epicentre** is the point on the surface directly above the focus.
4. Earthquakes occur at various depths, depending on the plates involved (Table 12.1).
   - Earthquakes at the surface tend to cause more damage.

TABLE 12.1 Classification of Earthquakes

Classification	Depth of Focus
Shallow focus	0 to 70 km
Intermediate focus	70 to 300 km
Deep focus	Greater than 300 km

Seismic Waves

1. Energy released by an earthquake produces vibrations called seismic waves.
   - Seismic waves reveal the source and strength of an earthquake.
   - Seismic waves also help us learn about the composition and size of Earth's interior layers since the waves behave differently in different layers.
     - Some seismic waves travel underground and are affected by the density of the material they travel through, which provides evidence of whether a layer is solid.
2. **Primary waves (P-waves)** are underground seismic waves that travel at about 6 km/s through Earth's crust, causing the ground to move in the direction of the wave's motion (Figure 12.8).
   - P-waves travel through solids, liquids, and gases.
   - P-waves are the fastest and are the first waves to arrive after an earthquake.

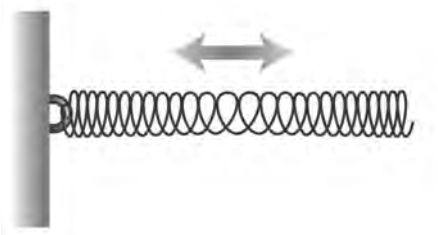


FIGURE 12.8 Primary waves illustration

3. **Secondary waves (S-waves)** are underground seismic waves that travel at about 3.5 km/s, causing the ground to move perpendicular to the direction of the wave's motion (Figure 12.9).
   - S-waves travel through solids but not liquids.
   - S-waves are slower and are the second waves to arrive after an earthquake.

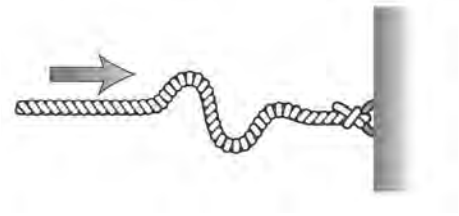


FIGURE 12.9 Secondary waves illustration

4. **Surface waves (L-waves)** are seismic waves that ripple along Earth's surface like ripples on a pond (Figure 12.10).
   - L-waves usually cause more structural damage than P-waves.
   - L-waves are the slowest and the last waves to arrive after an earthquake.

FIGURE 12.10 Surface waves illustration

Quick Check

1. What is the difference between the focus of an earthquake and the epicentre of an earthquake?

   _____

   _____

2. What are three kinds of earthquake waves and how do they differ?

   (a) _____

   _____

   (b) _____

   _____

   (c) _____

   _____

Measuring Earthquakes

1. **Seismometers or seismographs** are machines that measure and record seismic wave energy.
2. A **seismogram** is a graph that shows the arrival times and sizes of seismic waves produced by an earthquake, showing when an earthquake started, how long it lasted, and its magnitude (strength).
   - An increase of 1 in magnitude = 10× stronger
     Example: A magnitude 6 earthquake is 100× more powerful than a magnitude 4 earthquake.
3. Since seismic waves travel at different speeds, a time-distance graph can reveal the focus (Figure 12.11).

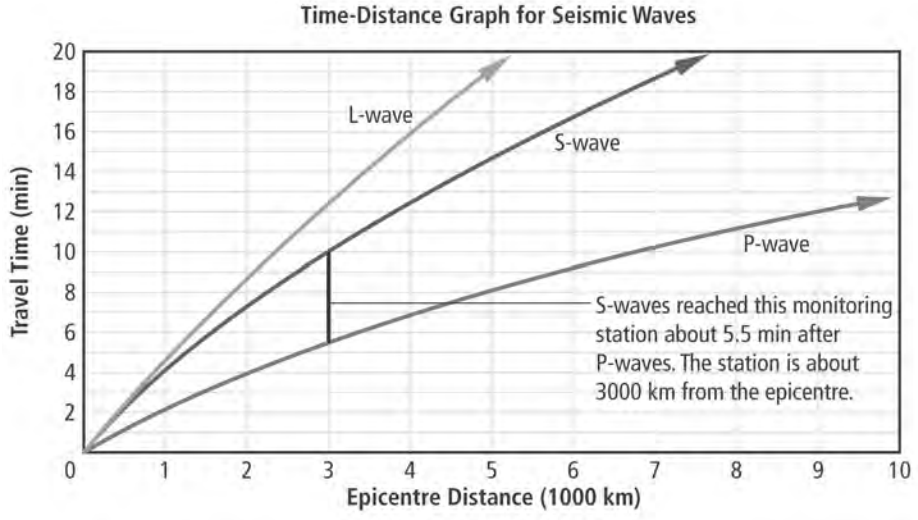


FIGURE 12.11 A time-distance graph shows how long it takes for different seismic waves to travel a certain distance.

Volcanoes

1. The movement of tectonic plates causes volcano formation.
2. Composite volcanoes are found along plate boundaries and are made of layers of ash and lava, which is magma on Earth's surface.
   - As magma reaches the surface, it cools, hardens, and traps gases below.
   - Pressure builds, and eventually there is an eruption.

3. Shield volcanoes form over hot spots.
   - Lava flows out from a hot spot and forms a low, wide cone.
   - The Hawaiian Islands are an example of a chain of shield volcanoes.
   - The Anaheim Volcanic Belt (see Data Pages, page 10) formed over a hot spot in the middle of British Columbia.
   - Yellowstone National Park in the United States has a series of volcanoes formed over a hot spot.
4. Rift eruptions occur along long cracks in the lithosphere, such as along the Mid-Atlantic Ridge.
   - These eruptions are not explosive, but they release massive amounts of lava.

Quick Check

1. List three types of volcanoes and state where each is found.

   _____

   _____

   _____

III. Sample Exam Questions Explained

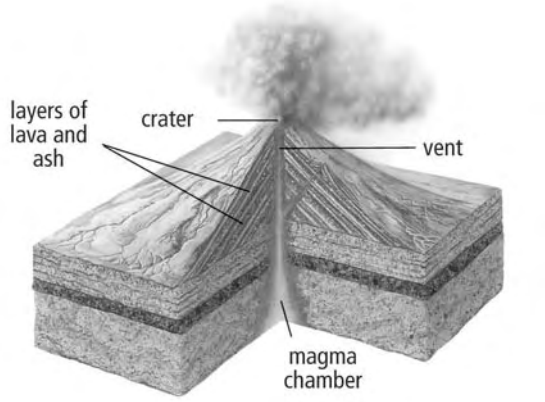
The Question	Why It Is Right/Why It Is Wrong
Refer to Map of the Pacific Coast of North America on page 10 of your Data Pages. Find the Juan de Fuca Plate, which is a small triangular plate that has a different kind of plate boundary on each side. What will happen to the Juan de Fuca plate in the distant future?	
A. It will be subducted under the North American plate and melt.	A. This answer is correct. Oceanic plates dive under continental plates. Arrows show the North American plate moving west as the Juan de Fuca plate moves east.
B. It will get larger and push the North American plate east as it moves west.	B. The Juan de Fuca plate is still growing at the Juan de Fuca ridge, but the entire ridge and plate will be subducted eventually.
C. It will form an island arc.	C. Island arcs form at the convergent boundary between two oceanic plates.
D. It will remain basically unchanged.	D. In the long term, all the oceanic plates in the world are subducted as continental plates pass over them.

➜ Why was this question asked?

This question was asked to determine if you understand how to read a map showing plate movements.

➜ Where can I get extra practice on this type of question?

- Use pages 523 to 526 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

The Question	Why It Is Right/Why It Is Wrong
	
What kind of volcano is shown in the diagram?	
A. composite	A. This answer is correct. Composite volcanoes are characterized by many layers of ash and lava, as well as violent eruptions. The composition of composite volcanoes is different from others because they are made of melted subducted crust.
B. shield	B. Shield volcanoes do not erupt explosively because they are not made from melted subducted crust.
C. rift	C. Rift eruptions occur along long cracks.
D. hot spot	D. Volcanoes that occur over hot spots are shield volcanoes. They are not made from melted subducted crust.

➜ Why was this question asked?

This question was asked to determine if you understand the three types of volcanoes.

➜ Where can I get extra practice on this type of question?

- Use pages 523 to 534 in *BC Science 10*.
- Go to www.bcscience10.ca for extra practice.

IV. Practice Questions

Section 12.2

Thermal energy transfer drives plate tectonics: Features of Plate Tectonics

Circle the letter of the best answer.

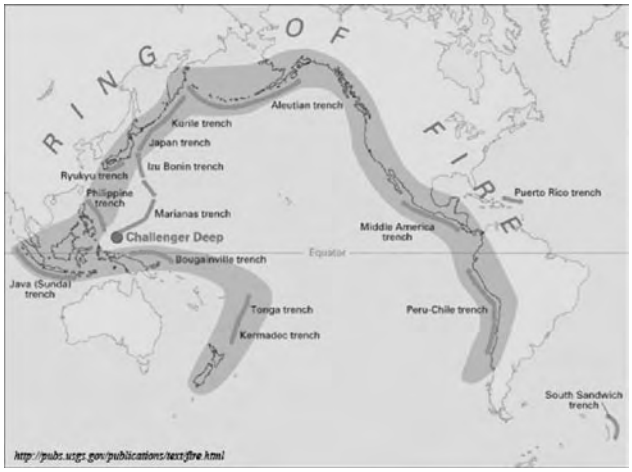
Use the photograph below to answer question 1.

1. The picture above is a part of the San Andreas Fault. What term best describes the San Andreas Fault?
   A. oceanic plate boundary
   B. divergent plate boundary
   C. transform plate boundary
   D. convergent plate boundary

2. What type of plate boundary has created the Himalayan Mountains?
   A. continental-continental plate convergence
   B. oceanic-continental plate convergence
   C. oceanic-oceanic plate convergence
   D. divergent plate boundary

3. If an earthquake occurred on the opposite side of Earth from you, what type of seismic wave might you experience?
   A. L-wave
   B. P-wave
   C. S-wave
   D. S-wave and L-wave

Use the map below to answer question 4.



4. The Pacific Rim is sometimes called the Ring of Fire because of the large amount of volcanic activity that occurs there. What is the main cause of this volcanic activity?
   A. divergent plates
   B. transform faults
   C. subduction zones
   D. earthquake epicentres

5. Why is the inner core of Earth solid?
   A. The inner core rotates more slowly than the outer core.
   B. The immense pressure keeps it solid.
   C. The inner core of Earth is very cold.
   D. Earth formed from a rocky mass.

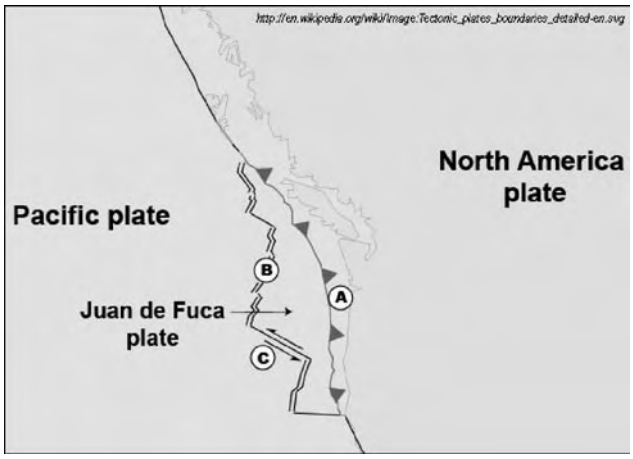
6. What type of seismic wave travels the fastest?
   A. L-wave
   B. P-wave
   C. S-wave
   D. both the P-wave and the L-wave

Use the photograph below to answer question 7.

7. The photo above is of Mount Taranaki in New Zealand. This volcano was made famous in the movie *The Last Samurai* posing as Mount Fuji. What type of volcano are both Mount Taranaki and Mount Fuji?

   A. rift
   B. shield
   C. oceanic
   D. composite

Use the map below to answer question 8.



8. Off of the south coast of British Columbia, we can find three different types of plate boundaries. In the image above, what are the plate boundaries located at A, B, and C, in that order?

   A. transform, convergent, divergent
   B. divergent, convergent, transform
   C. convergent, divergent, transform
   D. transform, divergent, convergent

9. Which of the following layers are components of the theory of plate tectonics?

I	lithosphere
II	asthenosphere
III	troposphere
IV	stratosphere

   A. I only
   B. I and II only
   C. I, II, and III only
   D. I, II, III, and IV

10. Which of the following are associated with an oceanic-oceanic convergent boundary?

I	volcanic island arc
II	suture zones
III	earthquakes
IV	ocean trenches

   A. I and III only
   B. I, II, and IV only
   C. I, III, and IV only
   D. II, III, and IV only

Processes of Science Vocabulary Terms

You may encounter the following Processes of Science vocabulary terms on the exam.

- ☐ **accuracy** the difference between a measurement and its accepted value
- ☐ **conclusion** the explanation of the results of an experiment as they apply to the hypothesis being tested
- ☐ **control** a test you carry out with no independent variables so you can observe whether your independent variable in an experiment does indeed cause a change
- ☐ **controlled experiment** an investigation in which only one variable is changed, and the resulting effect on another variable is observed, while all other variables are held constant
- ☐ **dependent variable** in an experiment, the factor that changes in response to a change in the independent variable; also called the responding variable
- ☐ **extrapolation** a prediction that is out of the range of the collected data
- ☐ **hypothesis** a testable proposal used to explain an observation or to predict the outcome of an experiment; often expressed in the form of an "If ..., then ..." statement
- ☐ **independent variable** in an experiment, the factor that is selected or adjusted to see what effect the change will have on the dependent variable; also called the manipulated variable
- ☐ **interpolation** a prediction that is within the range of collected data
- ☐ **observation** information gathered through one or more senses, including hearing, touch, sight, taste, and smell
- ☐ **precision** a measure of the detail, such as the number of digits, with which a quantity is expressed
- ☐ **prediction** a forecast about what you expect to observe when you do an investigation
- ☐ **principle** a fundamental law, assumption, or fact
- ☐ **procedure** a specific set of actions which if executed in the same manner under the same circumstances will yield the same results
- ☐ **scale** ratio between a single unit of distance, such as on a map, model, or drawing, and the corresponding distance in reality
- ☐ **scientific literacy** an evolving combination of the science-related attitudes, skills, and knowledge necessary to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world
- ☐ **slope** the direction of a line on a graph, which may be horizontal (zero), slanting up (positive), or slanting down (negative). Slope is calculated by determining the ratio of rise/run.
- ☐ **uncertainty** a lack of certainty; having limited knowledge to describe a state or outcome, often where more than one outcome is possible
- ☐ **validity** the degree to which a conclusion is likely to be true
- ☐ **variable** a factor that can influence the outcome of an experiment
- ☐ **Venn diagram** a type of graphic organizer that can be used to compare and contrast two or more concepts or objects by using two or more intersecting circles

Unit 4 Glossary

aerosol a suspension of fine solid or liquid particles in a gas

asthenosphere the molten layer of the upper mantle

atmosphere layers of gases that extend above Earth

atmospheric pressure the amount of pressure the molecules in the atmosphere exert at a particular location and time

barometer an instrument used to measure atmospheric pressure

climate change the change in long-term weather patterns in certain regions

condensation the change of state of a substance from gas form to liquid form

conduction the transfer of heat by direct contact of particles

continental drift theory a theory put forward by Alfred Wegener in the early 20th century that proposed that continents moved around Earth's surface and were at one time joined together

convection the transfer of heat energy in fluids where hot, less dense fluid rises and cold, denser fluid sinks

Coriolis effect a change in the direction of moving air, water, or objects due to Earth's rotation

cross-section a representation of a slice of an object, including its interior; in contrast, a map view shows only the object's surface

crust Earth's outermost, sold rock layer; continental crust is made from a less dense type of rock called granite, and oceanic crust is made from a dense rock called basalt

density the amount of mass contained in a given volume

earthquake a shaking of the ground as the result of a sudden release of energy in Earth's crust

El Niño unusually warm water on the surface of the Pacific Ocean that leads to warmer winters in the Pacific Northwest and in eastern Canada

El Niño Southern Oscillation (ENSO) the phenomena of El Niño and La Niña events and the accompanying changes in air pressure over the southern Pacific Ocean

energy budget Earth's balance of incoming and outgoing energy

epicentre the point on Earth's surface directly above the focus where an earthquake starts

evaporation the change of state of a substance from liquid form to gas form

fault a break or fracture in rock layers due to movement on either side

focus in geology, the location inside Earth where an earthquake starts

geological time scale a scale that describes the timing of and relationships between events in Earth's past

gradient slope; the change of a measurement over a specific distance and along a given direction, for example, a temperature gradient is a region where temperature changes from one measure to another

greenhouse gases atmospheric gases that absorb and emit radiation as thermal energy

heat the amount of thermal energy that transfers from an area or object of higher temperature to an area or object of lower temperature

heat budget See energy budget

heat flow the movement of thermal energy from a hotter object to a colder object

heat transfer the transfer of heat across a temperature gradient, from higher temperature, higher kinetic energy particles to lower temperature, lower kinetic energy particles; includes conduction, convection, and radiation

hot spot in geology, the location of excess radioactivity, causing magma to rise to Earth's surface

hurricane storm system with a low pressure centre that has strong winds, flooding rains, and many thunderstorms

inner core Earth's solid centre, made mostly of solid iron, which is at tremendous temperature and pressure

insulator in heat transfer, a material that does not transfer heat easily

kilopascal, kPa the SI unit that measures the vertical force of atmospheric pressure per unit area

kinetic energy energy due to motion

kinetic molecular theory a theory that explains that all matter is made up of tiny particles (atoms and molecules) that are constantly in motion

La Niña an upwelling that brings cooler than normal waters to the surface of the eastern Pacific Ocean

lithosphere the crust and upper portion of the mantle

magnetic polarity Earth's magnetic field and north and south magnetic poles; normal polarity is when Earth's magnetic poles are similar to its geographic poles, reverse polarity is when Earth's magnetic poles are opposite to Earth's geographic poles

magnetic reversal a reversal of Earth's magnetic polarity over thousands of years so that the magnetic north pole becomes the magnetic south pole and the magnetic south pole becomes the magnetic north pole

magnetometer a device that detects variations in magnetic fields

mantle Earth's thickest layer, lying just below the crust and making up about 70 percent of Earth's volume, mostly solid except for the upper mantle, which can flow like "thick toothpaste"

mantle convection thermal energy transfer in the mantle, where hot, light magma rises and cold, dense lithospheric plate material sinks

mantle plume an upwelling of extremely hot rock within Earth's mantle that forms hot spots

mid-ocean ridge underwater mountain range, such as the Mid-Atlantic Ridge running north to south down the length of the Atlantic Ocean

mountain range chain of mountains separated from other mountains or surrounded by lowlands

outer core the layer below Earth's mantle made of liquid iron and nickel

ozone layer a layer in the stratosphere that filters out harmful ultraviolet radiation from the Sun

paleoglaciation a term describing past periods of extensive glaciations that covered most of the continents

permafrost ground that usually remains frozen year-round

plate boundary the location where two plates meet and move relative to each other; convergent plate boundaries are areas where tectonic plates collide, divergent plate boundaries are areas where tectonic plates are spreading apart, and transform plate boundaries are areas where tectonic plates slide horizontally past each other

plate tectonic theory the theory that Earth's surface is made up of several lithospheric plates that move around relative to one another, sliding over the semi-fluid asthenosphere

potential energy the stored energy of an object or particle, due to its position or state

pressure the amount of force per unit area

prevailing winds winds that are typical for a location

primary waves (P-waves) underground seismic waves that travel at about 6 km/s through Earth's crust, causing the ground to move in the direction of the wave's motion

radiation the transfer of energy by waves through space

ridge push the process in which a spreading mid-ocean ridge pushes the rest of the tectonic plate it is on away from the ridge

rift valley a steep-sided valley formed on land where magma rises to Earth's surface at a spreading centre

sea floor spreading the process in which magma rises to Earth's surface at spreading ridges and, as it continues to rise, pushes older rock aside

secondary waves (S-waves) underground seismic waves that travel at about 3.5 km/s, causing the ground to move perpendicular to the direction of the wave's motion

seismogram a graph that shows the arrival times and sizes of seismic waves produced by an earthquake, showing when an earthquake started, how long it lasted, and its magnitude (strength)

seismograph See seismometer

seismometer a machine that measures and records seismic wave activity

slab pull the process in which the dense, subducting plate material pulls the rest of the attached plate toward the subduction zone and down into the mantle

spreading ridge the region where magma breaks through Earth's surface, continually forcing apart old rock and forming new sea floor

subduction the action of one tectonic plate pushing below another tectonic plate

subduction zone areas of subduction at convergent plate boundaries where one tectonic plate subducts beneath and is destroyed by the other overriding plate

supercontinent a landmass made up of more than one continent; an example is Pangaea, a landmass formed millions of years ago and made of all the continents

surface waves (L-waves) seismic waves that ripple along Earth's surface like ripples on a pond

surface winds winds near Earth's surface that are subjected to friction from the differences in geographic features

tectonic plates large, rigid movable slabs of rock at Earth's surface that slide over a layer of partly molten rock

temperature a measure of the average of the kinetic energy of all the particles in a sample of matter

thermal energy the total energy of all the particles in a solid, liquid, or gas

thermocline the transition zone that separates the cold, deep ocean waters from the Sun-warmed surface waters

tornado a "funnel" of rotating air that can extend all the way to the ground with winds of up to 400 km/h; can occur when high altitude horizontal winds meet thunderstorms

transform fault a fault that occurs at a transform boundary

trench a long narrow depression in the ocean floor that marks a convergent plate boundary and is part of a subduction zone

volcanic belt a long chain of volcanoes

volcanic island arc a long chain of volcanic islands

volcano an opening in Earth's surface that, when active, spews out gases, chunks of rock, and melted rock

wind the movement of air from an area of higher pressure to an area of lower pressure

Part C – Unit 4 Answer Key

Chapter 10

Quick Check Answers

page 6

1. The kinetic molecular theory explains that all matter is made up of tiny particles (atoms and molecules) that are constantly in motion.
2. Temperature is a measure of the average of the kinetic energy of all the particles in a sample of matter.
3. Thermal energy is the total energy of all the particles in a solid, liquid, or gas.
4. Heat is the amount of thermal energy that transfers from an area or object of higher temperature to an area or object of lower temperature.
5. (a) Iceberg
   (b) Hot cup of tea
   (c) Iceberg
   (d) From the tea to the iceberg

page 7

1. Conduction, convection, radiation
2. Conduction
3. Radiation
4. Convection

page 11

1. Nitrogen (N_2) and oxygen (O_2)
2. Sea level
3. Solar energy and thermal energy

page 13

1. Earth's surface absorbs solar radiation, heats up, and then radiates the thermal energy into the atmosphere.
2. Incoming and outgoing energy
3. Convection currents spread thermal energy around by causing some air masses to rise and others to fall.

page 14

1. (a) Atmospheric pressure is the amount of pressure the molecules in the atmosphere exert at a particular location and time.
   (b) Barometer
2. Sea level
3. Warm air is lighter and less dense than cool air, and therefore warm air has a lower pressure than cool air.
4. Wind is caused by the movement of air from areas of higher pressure to areas of lower pressure.
5. High pressure systems form when an air mass cools. As the high pressure airs sinks, it becomes warmer and drier, and as a result, high pressure systems often bring clear skies.
6. Low pressure systems form when an air mass warms. As the low pressure system rises, it cools, and condensation occurs, producing clouds or precipitation.

page 15

1. Prevailing winds in southern British Columbia are moist air masses from the Pacific Ocean that blow inland over the coastal mountains.
2. Hills and forests force the winds to slow down and change direction, whereas a calm ocean surface does not create as much friction.
3. Offshore breezes
4. Onshore breezes occur at night when warm air over the water rises and draws in the cool air from over the land.

page 17

1. The Coriolis effect is a change is the direction of moving air, water, or objects due to Earth's rotation.
2. Trade winds, prevailing westerlies, polar easterlies
3. A weather front is a boundary between two air masses each with its own temperature and pressure.
4. Extreme weather events are caused when air masses release large amounts of energy.
5. Thunderstorms, tornadoes (waterspouts), hurricanes (cyclones, typhoons)

Practice Questions Answers

Section10.1

1. B
2. A
3. A
4. B
5. C
6. C
7. C
8. A
9. B
10. C

Section 10.2

1. C
2. C
3. D
4. A
5. D
6. B
7. D
8. B
9. C
10. C

Chapter 11

Quick Check Answers

page 22

1. Climate describes the average conditions of a region over 30 years or more, including clouds, precipitation, average temperature, humidity, atmospheric pressure, solar radiation, and wind.
2. Fossils, tree rings, glacier ice cores

page 23

1. The natural greenhouse effect is the absorption of thermal energy by the atmosphere, which keeps Earth's temperature within a certain range.
2. 34°C
3. Tilt, rotation, orbit
4. Tilt

page 24

1. Water vapour
2. Water temperature and water salinity
3. A thermocline is the transition zone that separates the cold, deep ocean waters from the Sun-warmed surface waters.

page 25

1. In an El Niño year, unusually warm water on the surface of the Pacific Ocean leads to a warmer winter in the Pacific Northwest and eastern Canada.
2. (a) Deep oceans, mature forests
   (b) Weathering of rocks, forest fires, decaying vegetation
3. Erupting volcanoes can release ash and molten rock that absorb radiation, preventing it from reaching the surface of the Earth. Water vapour and sulfur dioxide (changed into sulfuric acid) can reflect solar radiation back into space.
4. Comets strike Earth, and the result is large quantities of dust, debris, and gases in the atmosphere, which reduce the amount of solar radiation that reaches Earth's surface.

page 31

1. CFCs have a global warming potential that is between 4750 and 5310 times greater that CO_2.
2. CO_2
3. The enhanced greenhouse effect is the increased capacity of the atmosphere to absorb and emit thermal energy because of an increase in greenhouse gases.

page 32

1. The ozone layer filters out harmful ultraviolet radiation from the Sun.
2. At lower altitudes, ozone is a powerful greenhouse gas
3. Snow-covered areas reflect the Sun's radiation particularly well
4. Ocean water has a low albedo. As ice disappears and is replaced by liquid water, much more solar radiation is absorbed.

page 34

1. Any six of: rising sea levels, water conflicts, greater disease risk, increased severity of tropical storms, increased frequency of tropical storms, decreasing crop yields, increasing deforestation, changes in fisheries
2. Any six of: reduce vehicle greenhouse gas emission, reduce industrial greenhouse gas emissions, increase use of energy-efficient products, improve indoor air quality, improve fertilizer use, promote worldwide planting of trees, promote recycling, composting, minimizing waste

Practice Questions Answers

Section 11.1

1. C
2. D
3. A
4. B
5. C
6. B
7. D
8. C
9. B
10. A

Section 11.2

1. C
2. B
3. D
4. B
5. A
6. D
7. B
8. A
9. B
10. C

Chapter 12

Quick Check Answers

page 39

1. The shapes of the continents seemed to fit together like jigsaw pieces.
2. Similar geologic features (similar rocks) were found on different continents, matching fossils on different continents, evidence of different climates (such as coal in Antarctica)

page 40

1. Wegener could not explain how continents drifted.
2. (a) The centre of the Atlantic Ocean is marked by a volcanic ridge that runs the entire length of the Atlantic Ocean from north to south, and where new land forms.
   (b) Rocks near the Mid-Atlantic ridge are younger than rocks farther away from the ridge, and sediments at the edges are deeper (suggesting they are older).
   (c) Magnetic striping patterns on the floor of the Atlantic Ocean show mirror images on either side of the Mid-Atlantic ridge, suggesting the sea floor is spreading outwards from the ridge.
3. The Hawaiian Islands formed as a tectonic plate passed over a hot spot and magma rose up from under Earth's surface.
4. The plate tectonic theory states that Earth's surface is broken into large plates that move apart and then rejoin, sliding over the semi-fluid rock below.

page 47

1. (a) Inner core
   (b) Outer core
   (c) Mantle
   (d) Crust
2. Oceanic crust is denser than continental crust.
3. Heat from the Earth's core
4. (a) The lithosphere includes the crust and the upper part of the mantle.
   (b) The asthenosphere includes the upper part of the mantle that is molten.
5. A mantle plume is an upwelling of extremely hot rock within Earth's mantle that forms hot spots.
6. Rift valleys form on land as rising magma reaches the surface and spreads in two opposite directions, pulling plates apart.
7. Subduction is the action of one plate pushing below another.

page 49

1. Diverging, converging, transform
2. (a) Island arc
   (b) Volcanic belt at the edge of the continent
   (c) High folded mountains
   (d) Rift valley
   (e) Mid-oceanic ridge
3. They slide past each other in opposite directions

page 51

1. The focus of an earthquake is where the pressure is finally released. The epicentre is the point on the surface directly above the focus.
2. In any order:
   (a) P-waves are underground seismic waves that travel the most quickly through Earth's crust, causing the ground to move in the direction of the wave's motion. They can travel through solids, liquids, and gases.

(b) S-waves are underground seismic waves that travel slower, causing the ground to move perpendicular to the direction of the wave's motion.
(c) S-waves travel through solids but not liquids. L-waves are seismic waves that ripple along Earth's surface like ripples on a pond. L-waves usually cause more structural damage than P-waves or S waves.

page 52

1. In any order:
   (a) Composite volcanoes are found along plate boundaries.
   (b) Shield volcanoes form over hot spots.
   (c) Rift eruptions occur along long cracks in the lithosphere, such as along the Mid-Atlantic Ridge.

Practice Questions Answers

Section 12.1

1. A
2. D
3. B
4. C
5. C
6. B
7. D
8. D
9. B
10. D

Section 12.2

1. C
2. A
3. B
4. C
5. B
6. B
7. D
8. C
9. B
10. C